EVALUATING THE IMPACT OF INPATIENT PAIN MANAGEMENT INTERACTIVE SYSTEMS

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DEDICATION

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ABSTRACT

EVALUATING THE IMPACT OF INPATIENT PAIN MANAGEMENT INTERACTIVE SYSTEMS

The management of patients' pain is essential for improving the overall quality of patient care. Equally important, is the patient's role in managing their pain and the health system's role in creating the ideal environment that supports high quality patient-centered care. Accordingly, many hospitals have and are investing in patient engagement technology systems aimed in supporting patients in their pain management care process. Despite the decade-plus existence of pain interactive entertainment systems, which are designed to distract patients from pain during treatment, their role in the management of pain remains understudied. Some of these interactive systems, in addition to their entertainment features, also include other functions to deliver standardized patient education and support the integration of patient-reported pain assessments into the electronic health record (EHR). However, despite technological advances that support this integration, this functionality is rarely implemented and researchers have rarely studied the effects of adopting interactive pain management systems (IPMS) in the inpatient setting. The objectives of this body of research are to address this gap in knowledge by evaluating various aspects of IPMS. The study was conducted in four phases: 1) examining the current evidence around and the state of IPMS, 2) evaluating the effect of a novel IPMS at the University of Minnesota Masonic Children's Hospital (UMMCH), 3) characterizing user experience and satisfaction with use of IPMS and 4) understanding the population that utilizes the inpatient IPMS for the management of pain.

We conducted a systematic literature review across seven databases to understand the current state of IPMS in an inpatient setting and examine their clinical outcomes. Out of the reviewed full-text articles, 17 were eligible and included in the final qualitative synthesis. Overall, there were two main types of IPMS within the inpatient setting; stand-alone systems and integrated platform systems. Reports examined a variety of outcome measures, including changes in patient-reported pain levels, patient engagement, user satisfaction, changes in clinical workflow, and changes in documentation. In our second study, we conducted a mixed methods case study approach to describe the development of a IPMS at the UMMCH and to evaluate the impact of implementation on clinical workflow, patient use, and compliance with nursing documentation of their pain reassessments. We employed a retrospective analysis of 56,931 patient records covering pre- and post-implementation. Despite nursing pain reassessment documentation being relatively low, implementation of the system led to a statistically significant increase in the overall nurse documentation and resulted in patient access to nonpharmacologic strategies to eliminate pain. In our third study, benefits and challenges on the use of an inpatient IPMS were identified by parents and nurses. Overall, there was a cohesive agreement among users regarding the impact of the IPMS in engaging and empowering patients/families, increasing patient satisfaction, and creating a communication platform, with the most usefulness feature being "Support of Timely Pain Reassessments". Thematic content analysis was conducted to analyze nurse responses and identify high level themes. Six themes emerged related to "Benefits" from using the system: *Phone Reminders, EHR Automatic Documentation, Decision Support, Patient Empowerment, Sense of Connection* and *Non-Medication Resources.* There were also 12 "Challenges": *Uncertainty of Patient*

Rating Scores, Training Needs, Distraction, Discourage Best Practice, Low Utilization, Low Utilization Due to Environmental Factors, System Design Limitations, Pain Scale Discrepancy, Low Utilization Due to Patient Factors, Patient/Family Dissatisfaction, Workflow and *Duplicate Charting Requirement.* The ability to identify user experience associated with the use of these systems, potentially assists in designing IPMS to maximize positive impact on clinical outcomes and care quality. Finally, by conducting a retrospective analysis of inpatient records, our fourth study demonstrated differences in the patients' IPMS usage among different hospital units based on the care and medical service these units provide and an increased usage was associated with the time of medication administration. Overall, this research collectively demonstrated the benefits of IPMSs and showed the potential of these systems in improving the patient and provider experience and the quality of care. Evaluating the effects of these systems on clinical outcomes, patient satisfaction, hospital workflow, and barriers and facilitators associated with the use of these systems is an important component in developing meaningful health information technology (HIT) systems to engage patients and address pain.

TABLE OF CONTENTS

ACKNOWLEDGMENTS ..... **I**

DEDICATION ..... **IV**

ABSTRACT ..... **V**

LIST OF TABLES ..... **X**

LIST OF FIGURES ..... **XI**

ABBREVIATIONS ..... **XII**

CHAPTER 1: INTRODUCTION **1**

1.1 Background and Significance 1
1.2 Patient Engagement Health Information Technology Systems 2
1.3 Automation of Pain Assessment Tools 3
1.4 Automatic Clinical Documentation within the EHR 3
1.5 Novel Pain Management Interactive System 4
1.6 Specific Aims 6

CHAPTER 2: THE IMPACT OF PATIENT INTERACTIVE SYSTEMS ON THE MANAGEMENT OF PAIN IN AN INPATIENT HOSPITAL SETTING: A SYSTEMATIC REVIEW **8**

2.1 Summary 9
2.2 Background and Significance 10
2.3 Objectives 11
3.4 Methods 12
3.4.1 Search Strategy *12*
3.4.2 Screening and Study Selection *13*
3.3.3 Data Extraction and Classification *13*
2.4. Results 15
2.4.1 Study Quality *15*
2.4.2 Types of Pain Management Interactive Systems *18*
2.4.3 Outcome Measures *24*
2.5 Discussion 31
2.6 Conclusion 33

CHAPTER 3: LINKING PEDIATRICS PATIENTS AND NURSES WITH THE PHARMACY AND ELECTRONIC HEALTH RECORD SYSTEM THROUGH THE INPATIENT TELEVISION: A NOVEL INTERACTIVE PAIN-MANAGEMENT TOOL **34**

3.1 Summary 35
3.2 Background 37
3.3 Methods 38
3.3.1 Pain Management Interface Development *38*
3.3.2 Evaluation *40*
3.3.3 Analysis *41*
3.4 Results 41
3.4.1 Patient/Parent Utilization Rates *42*
3.4.2 Changes in Nursing Timely Pain Reassessments *42*
3.5 Discussion 43
3.6 Conclusion 44

CHAPTER 4: USING A BEDSIDE INTERACTIVE TECHNOLOGY TO SOLICIT AND RECORD PEDIATRIC PAIN REASSESSMENTS: PARENT AND NURSING PERSPECTIVES ON A NOVEL WORKFLOW **45**

4.1 Summary 46

4.2 BACKGROUND 47
4.3 METHODS 48
4.3.1 Hospital Setting and the Pain Management Solution *48*
4.3.2 Clinical Workflow *49*
4.3.3 Study Design *50*
4.3.4 Data and Statistical Analysis *52*
4.4 RESULTS 53
4.4.1 Participants *53*
4.4.2 Perceived Usefulness of the Tool *55*
4.5 DISCUSSION 61
4.6 CONCLUSION 64

CHAPTER 5: UNDERSTANDING THE PEDIATRIC INPATIENT POPULATION USE OF PATIENT INTERACTIVE TOOLS IN THE MANAGEMENT OF PAIN 65

5.1 INTRODUCTION 66
5.2 METHODS 66
5.3 RESULTS 67
5.4 DISCUSSION 69

CHAPTER 6: CONCLUSIONS 71

BIBLIOGRAPHY 76

LIST OF TABLES

Table 2.1. Details of Reviewed Studies ….……...…..…… 19

Table 2.2. Reported Outcome Measures from Reviewed Studies …..……..…… 25

Table 3.1. Patient/Parent Responses to the Helping With Pain Question …..…… 42

Table 3.2. Nursing Pain Reassessment Documentation Rates (Documentation Frequency and Timeliness) …… 43

Table 4.1. Parent Participant Demographics ……..…… 53

Table 4.2. Nurse Participant Demographics …..……..…… 55

Table 4.3. Benefits and challenges to the use of the pain management tool ….…… 59

Table 5.1. Patient Demographics and Response per Unique Patient ……..…… 67

Table 5.2. Association Between Patient Use (responses) and Other Characteristics 68

LIST OF FIGURES

Figure 1.1. Pharmacy Orders Interface Pre and Post IPMS ….……..…… 5

Figure 1.2. Pain Assessment/Reassessment Documentation with the EHR ……. 6

Figure 2.1. PRISMA diagram ……..…. 14

Figure 2.2.A The risk of bias assessment with GRADE for Randomized Controlled Trials. Risk of bias summary ……..…… 16

Figure 2.2.B The risk of bias assessment with GRADE for Randomized Controlled Trials. Risk of bias graph ……..…… 17

Figure 2.3.A The risk of bias assessment with the ROBINS-I tool for Non-Randomized Controlled Trials. Risk of bias summary ……..….. 17

Figure 2.3.B The risk of bias assessment with the ROBINS-I tool for Non-Randomized Controlled Trials. Risk of bias graph …..……..… 18

Figure 3.1. Overview of the IPMS clinical workflow …..……..…..… 40

Figure 4.1: Perceived usefulness of the tool based on parents' responses ….…… 56

Figure 4.2: Perceived usefulness of the tool based on nurses' responses …..…… 57

ABBREVIATIONS

CMS - Centers for Medicare & Medicaid Service

EHR - Electronic Health Record

FLACC - Face, Legs, Activity, Cry, and Consolability

HCAHPS - Hospital Consumer Assessment of Healthcare Providers and Systems

HIT - Health Information Technology

HITECH - Health Information Technology for Economic and Clinical Health

IPC - Interactive Patient Care

IPMS - Interactive Pain Management Systems

IT - Information Technology

MECIR - Methodological Expectations of Cochrane Intervention Reviews

MIPS - Merit-based Incentive Payment System

PCA - Patient-Controlled Analgesia

PGHD - Patient-Generated Health Data

PMI - Pain Management Interface

PRI - Pain Rating Index

PROs - Patient Reported Outcomes

RCT - Randomized Controlled Trials

RN - Registered Nurse

UMMCH - University of Minnesota Masonic Children's Hospital

VR - Virtual Reality

CHAPTER 1: INTRODUCTION

1.1 Background and Significance

Acute pain is one of the most common adverse stimuli experienced by children.[1] If pain is not treated in a timely and effective manner it can lead to adverse physical and psychological patient outcomes for patients and their families.[2] Unmanaged patient pain may also cause negative effects on the hospital's performance metrics which often incorporate patient feedback on how well pain was addressed.[3] One of the critical elements of pain management is the process of patient pain reassessment.[4] Many professional organizations focus on this critical component in care by developing standards and guidelines to ensure the efficiency and effectiveness of this process. The National Guideline Clearinghouse[5] and Joint Commission[6] are among several key organizations that have developed standard guidelines related to the management and documentation of acute pain in healthcare organizations. These standards mainly focus on the two main components of the pain management process: (1) the methods and tools being adopted by the hospital for the assessment of pain and (2) the timely documentation of patient pain reassessment. Systems that support patient-provider communication of pain are also essential to effectively managing pain. Other professional organizations such the American Pain Society Quality of Care Committee[7] have revised and expanded guidelines (1995 Quality Improvement Guidelines for the Treatment of Acute Pain and Cancer Pain)[8] and facilitated improvements in the quality of pain management in all care settings. Their published report highlights the importance of hospitals to engage patients and their families in the pain management plan and to perform regular reassessment of patients' pain as part of a hospital wide pain management program.[8] In the inpatient pediatric population,

guidelines have highlighted the key role of parents (or other primary caregivers) of hospitalized children serving as patient proxies, adding an additional level of complexity to the overall pain management clinical workflow.[9,10] With these best practices being shared and set forth, many hospitals have relied on HIT systems to assist in supporting with the compliance to these mandates within the healthcare delivery process.

1.2 Patient Engagement Health Information Technology Systems

Health information technology systems, which are designed with patients being the core component in the care delivery process, create an environment for promoting patient engagement. This "patient engagement" component is crucial for improving health outcomes, increasing patient awareness, and enhancing patient healthcare satisfaction.[11,12] Engagement may occur during the care experience, within the outpatient clinic or inpatient ward, within the health care organization as a system, and within the larger community as a whole.[13] Promoting patient and family engagement is one of the aims of the Merit-based Incentive Payment System (MIPS) program's Advancing Care Information, which includes the previously known as "Meaningful Use" initiative within the Medicare and Medicaid Electronic Health Record Incentive Program under the Health Information Technology for Economic and Clinical Health (HITECH) Act.[14] Others have developed frameworks for improving quality and patient safety through patient and family engagement and described different factors that may potentially affect these outcomes.[15]

As such, patient and family engagement initiatives have been the focus of many decision-makers in the healthcare industry. Healthcare organizations are increasingly converging on the adoption of patient-facing systems such as personal health records,

patient portals, patient interactive technologies, and other forms of patient- and family-centered tools in the outpatient setting. However, there are technical and resource limitations to realizing the full potential of EHR technology for engaging patients in the inpatient setting,[16] including lack of HIT patient engagement tools [17] and lack of HIT intervention evaluation studies.[18] Prey et al. through their systematic review identified a scarcity of research related to approaches in fostering engagement in the inpatient setting and identified the need for future research that focuses on rigorously evaluating the impact of HIT systems on health outcomes and cost-effectiveness.[19]

1.3 Automation of Pain Assessment Tools

Previous studies have summarized various technology tools to supplement chronic pain management regimens.[20–22]Although electronic pain assessment tools have been used in hospitals for more than a decade,[23] these tools have only gained widespread use with the introduction of personal digital technologies.[24] Research evaluation studies focusing on the features of electronic pain assessment tools [25,26] and the potential benefits they offer in comparison with paper tools[27] have appeared. Patient interactive technologies designed for the management of pain have also emerged, such as electronic diaries,[10,27] computer assisted interviews,[28] and interactive tools.[29] Despite the existence of these electronic pain assessment tools, very few have been integrated with the hospital's EHR system to support automatic pain reassessment documentation and patient access to information.

1.4 Automatic Clinical Documentation within the EHR

As healthcare systems increasingly focus on patient-centered care, the opportunity for hospitals to automatically incorporate patient-reported outcomes (PROs) in the pain management care process arises.[30–32] The National Academy of Medicine identified

measures that capture standardized social and behavioral data in EHRs to assist in meeting the requirements for the MIPS in the use of EHRs.[33] The major benefits for hospitals in incorporating PROs into EHRs include a standardized process and a potentially efficient clinical documentation and workflow.[34,35]

Early adoption of HIT systems in capturing patient clinical data in the EHR to support decision making can be seen in the role of bedside monitors, infusion pumps, and mechanical ventilators within the intensive care.[36] Patient-generated health data (PGHD) has also received attention by many healthcare organizations. Many technology tools have been developed that allow for the capture of PGHD within the EHR such as patient portal devices to document patient history, home health monitoring equipment for obtaining biometric data and mobile apps for recording diet and exercise lifestyle information.[37] The focus on automatic capture of patient clinical data is driven not just by MIPS Incentive Program, but also for the potential advantages of utilizing this information proactively to positively impact patient care, the potential to drive better patient outcomes, to reduce the documentation burden on providers and to improve the quality of data stored in the EHR.[38]

1.5 Novel Pain Management Interactive System

In December 2014, UMMCH implemented a novel inpatient IPMS to support patient engagement and automatic documentation with the hospital's EHR system. The interactive system was built to alert nurses for timely pain reassessment and documentation, engage patients and their families in pain management care, improve regulatory documentation compliance, and provide patient access to nonpharmacologic strategies to eliminate pain. This system integrates four stand-alone hospital technology systems (a television- based interactive patient care tool, EHR system, nursing call system,

and pharmacy inventory management system), to allow for timely reassessment of patient's pain after medication is given and to support auto-documentation within the EHR. The system's pain reassessment medication trigger was developed from the hospital's formulary of 55 pain medications, designed to trigger the pain management workflow at a specific time based on the hospital's nursing pain reassessment policy.[39] The pharmacy's orders interface describing the pre and post IPMS implementation is shown in Figure 1.1.

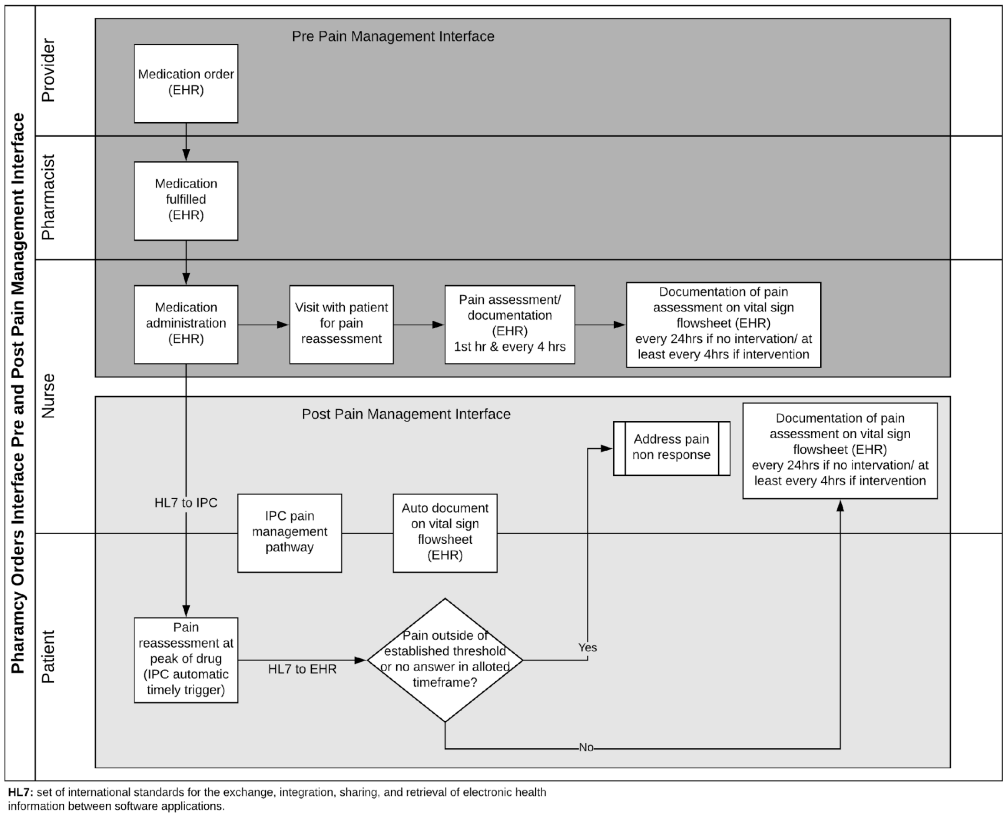

Figure 1.1. Pharmacy Orders Interface Pre and Post IPMS

According to the UMMCH's nursing standards, patient pain assessments/reassessments documentation should occur in the EHR's "Peds Vital Signs Complex" tab under the "Pain/Comfort Flowsheet" shown in Figure1.2. Documentation is stored in one or more of the following flowsheet display fields: (0-10 Pain Scale, CRIES

Score, FACES Pain Rating, FLACC Score, Legs (rFLACC Pain Rating: Activity), Nonverbal Indicators of Pain, N-PASS Score, Physiologic Indicators of Pain: BP, Physiologic Indicators of Pain: Heart Rate, Physiologic Indicators of Pain: O2 Sat, Physiologic Indicators of Pain: Respirations, Response to Interventions, Total Score) (shown in red in Figure 1.2). With the implementation of the novel IPMS, an additional pain reassessment documentation field under the "Pain/Comfort Flowsheet" was added, which represents the patient/parent engagement with the system (shown in green in Figure 1.2).

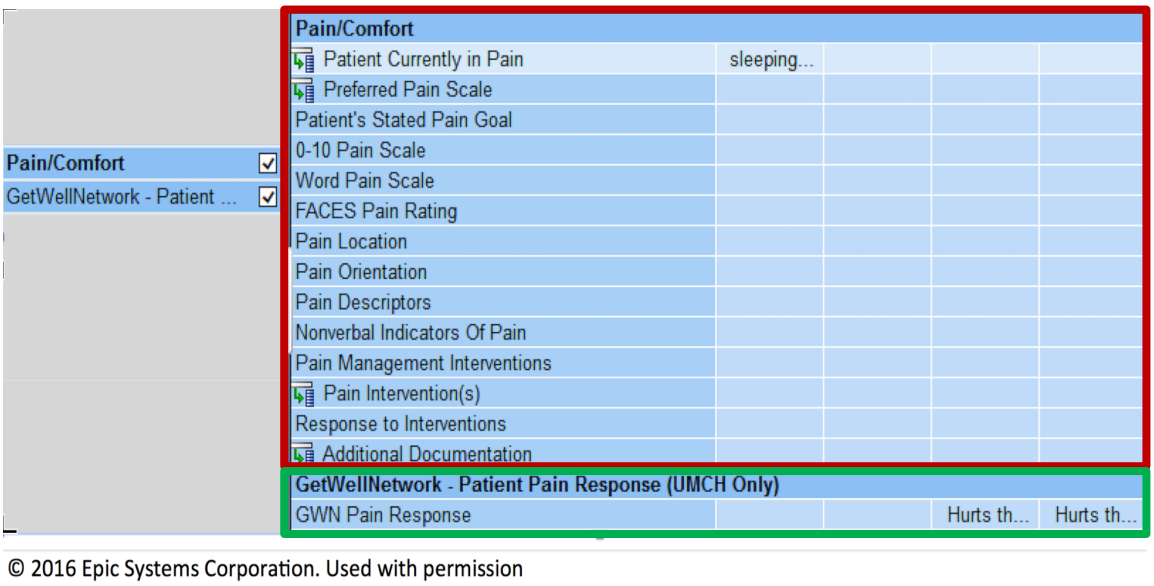

Figure1.2. Pain Assessment/Reassessment Documentation with the EHR

1.6 Specific Aims

The overall goal of this dissertation is to understand the current state of inpatient IPMS and evaluate their impact on hospital workflows, patient clinical outcomes, and patient satisfaction. This research also seeks to evaluate the impact of a novel IPMS

implemented at the UMMCH, as a case study. The specific research aims to support this goal are:

1. Examine the current state of scientific literature describing the use of IPMS within an inpatient hospital setting including their effects on patient and clinical outcomes.
2. Evaluate the effect of implementing a novel IPMS at the UMMCH on the hospital's pain-management clinical workflow, patient use, and nursing pain reassessment documentation practices.
3. Identify user perceptions in regards to experience of use, potential benefits and barriers, and general satisfaction with the use of the novel inpatient IPMS.
4. Understand the population that utilizes IPMS and identify use patterns.

Evaluating the effects of using an inpatient IPMS from different perspectives can potentially assist in designing these systems to maximize positive impact on patient engagement, pain management, and care quality. Overall, this research demonstrates the novelty in the use of a IPMS in an inpatient setting. It also contributes to the research body related to evaluating the impact and outcomes of implementing inpatient HIT systems, which support health care delivery for children and fosters engagement in the inpatient setting. Findings from this research can inform other hospitals about feasibility and potential areas to focus on when implementing meaningful inpatient interactive systems. Findings also have implications on system design and user training through uncovering opportunities for designing patient tailored programs specific to the characteristics and preferences of patients/parents to increase patient engagement in an inpatient setting.

CHAPTER 2: THE IMPACT OF PATIENT INTERACTIVE SYSTEMS ON THE MANAGEMENT OF PAIN IN AN INPATIENT HOSPITAL SETTING: A SYSTEMATIC REVIEW

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2.1 Summary

Background: While some published literature exists on the use of interactive patient care systems, the effectiveness of these systems on the management of pain is unclear. To fill this gap in knowledge, we aimed to understand the impact and outcomes of pain management patient interactive systems in an inpatient setting.

Methods: A systematic literature review was conducted across seven databases, and results were independently screened by two researchers. To extract relevant data, critical appraisal forms were developed and each paper was examined by two experts. Information included patient interactive system category, patient population and number of participants/samples, experiment type, and specific outcome measures.

Results: Out of 56 full-text articles assessed for eligibility, 17 were eligible and included in the final qualitative synthesis. Overall, there were two main types of pain management interactive systems within the inpatient setting (stand-alone systems and integrated platform systems). While systems were diverse especially for integrated platforms, most reported systems were entertainment distraction systems. Reports examined a variety of outcome measures, including changes in patient reported pain levels, patient engagement, user satisfaction, changes in clinical workflow, and changes in documentation. In the 12 systems measuring pain scores, 11 demonstrated a positive impact on pain level scores.

Conclusion: Pain management systems appear to be effective in lowering patient level scores, but research comparing the effectiveness and efficacy of one type of interactive system vs. another in the management of pain is needed. While not conclusive, pain management systems integrated with other technology platforms show potentially promising effects with improving patient communication, education, and self-reporting.

2.2 Background and Significance

The management of acute pain in a hospital setting is a multifaceted, complex process made no less complicated by the fact that each patient's experiences with pain is subjective and unique. Providers are being taught to consider pain as the "sixth vital sign," with this emphasis reinforced by the priority placed on patient feedback on how their pain was managed on the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey, the most widely used metric for patient satisfaction.[40] Successful pain management goes beyond simply reacting to acute pain with medication, as evidenced by the Joint Commission, hospitals are required for hospitals to involve patients in pain management treatment planning, to educating patients on pain management discharge plans, and to providing nonpharmacologic pain treatment modalities.[41]

Individuals experience pain differently, with demographic factors such as race/ethnicity, age, and gender[42,43]and psychological factors such anxiety and past experiences[44,2] possibly impacting how patients perceive and respond to the treatment of pain. Complicating things further, patient satisfaction with pain control is not the same as patients simply endorsing the absence of pain. In fact, Pronovost *at el*, showed that patients were more likely to rate their overall satisfaction high if they perceived that their care providers did everything possible to control pain, regardless of how much pain the patients were actually in.[3]

In response to this need for individualized approaches, hospitals are turning to information technology (IT) to develop and implement systems to support an optimal multifaceted pain management process. Many of these applications have focused on automation of the pain assessment and documentation process,[45,46,47]or on the use of mobile

applications to engage patients in tracking and managing their pain.[48,49] Web-based intervention systems create opportunities to enhance patient education and engagement via interactivity,[50,51] defined as the "extent to which users can participate in modifying the form and content of a mediated environment in real time".[52]

Patients who are more actively involved in their health care experience better health outcomes, lower health costs, and higher levels of satisfaction.[53,54,55] The use of patient interactive systems in the management of pain have been reported in the literature since the early 2000's when virtual reality (VR) systems were introduced to distract patients during painful therapy or treatment. In more recent years, the use of these systems has extended beyond a means of distraction to serve as a platform for patient-provider communication and an enhance access to patient standardized patient education. These systems can potentially allow for a more patient-centered care approach and an improved clinical workflow.

Previous systematic reviews explored patient engagement systems,[56] demonstrated the effects of patient interactive systems on patient engagement [57] and their impact on patients' self-management of health, such as diabetes,[58] asthma,[59] weight loss,[60] and smoking cessation.[61] To our knowledge no review has been conducted on the impact of patient interactive systems on pain management, particularly in an inpatient setting.

2.3 Objectives

We aimed to summarize the current state of scientific literature regarding the use of patient interactive systems designed for the management of pain within an inpatient hospital setting. Specifically, we sought to determine whether patient engagement through

the use of interactive systems for pain management lead to improvements in clinical care, clinical workflows, patient outcomes, or user satisfaction.

3.4 Methods

3.4.1 Search Strategy

We systematically searched the literature to capture all publications relating to the impact of patient engagement and the use of interactive systems on clinical care, workflows, patient-reported outcomes, and user satisfaction. We registered the review protocol in PROSPERO,[62] and conducted searches across 8 databases: MEDLINE and Embase (both via Ovid), Cochrane Library (via Wiley), Web of Science, Scopus, Global Index Medicus, ClinicalTrials.gov, and WHO ICTRP. Additionally, we consulted the reference lists of relevant systematic reviews and hand-searched conference proceedings. In accordance with MECIR guidelines,[63] we employed a combination of controlled vocabulary and natural language and we placed no limitations on date of publication or language. A complete search strategy is available in the appendix. Results were compiled and deduplicated using EndNote (Version X7).[64]

Studies that describe the implementation or use of a patient interactive system for the management of pain in an inpatient hospital setting were included in this review. Exclusion criteria included reports exclusively in outpatient or home care settings, not utilizing an interactive pain management system, and not engaged in pain management activities. Articles that did not report original data, such as narrative reviews or opinion pieces, were also excluded.

3.4.2 Screening and Study Selection

Three experienced researchers (health information professional, health informatics professional and medical doctor) conducted the screening. Two independent screeners (R.A and M.P) reviewed each title and abstract for inclusion using Rayyan, a web application that supports collaboration among researchers during screening and study selection.[65] Where discrepancies existed between the two screeners, a decision was reached through discussion or, where necessary, by a third screener (K.B). Full-text screening followed title and abstract screening, again with the two independent screeners determining inclusion. Screeners recorded rationale for exclusion, which is reported in a PRISMA diagram (Figure 2.1).[66]

3.3.3 Data Extraction and Classification

We developed data extraction forms that captured whether articles reported on specific outcome measures: (1) changes in clinical workflow; measuring a set of outcomes measures, which include pre and post comparison studies, (2) patient engagement; measuring dimensions of patient participation, patient activation, patient engagement, patient motivation, or self- efficacy through patient reports, validated surveys such as the Patient Activation Measure, the Altarum Consumer Engagement Measure, or measures defined by authors such as "sense of presence",[67] (3) user satisfaction (patient, parent, or nurse); measured through patient reports, validated surveys, or qualitative measures such as patient interviews, (4) changes in patient reported pain level scores; measured through a validated clinical pain assessment tool, and (5) changes in electronic health record pain documentation; measuring a set of outcomes measures, which include pre and post comparison studies.

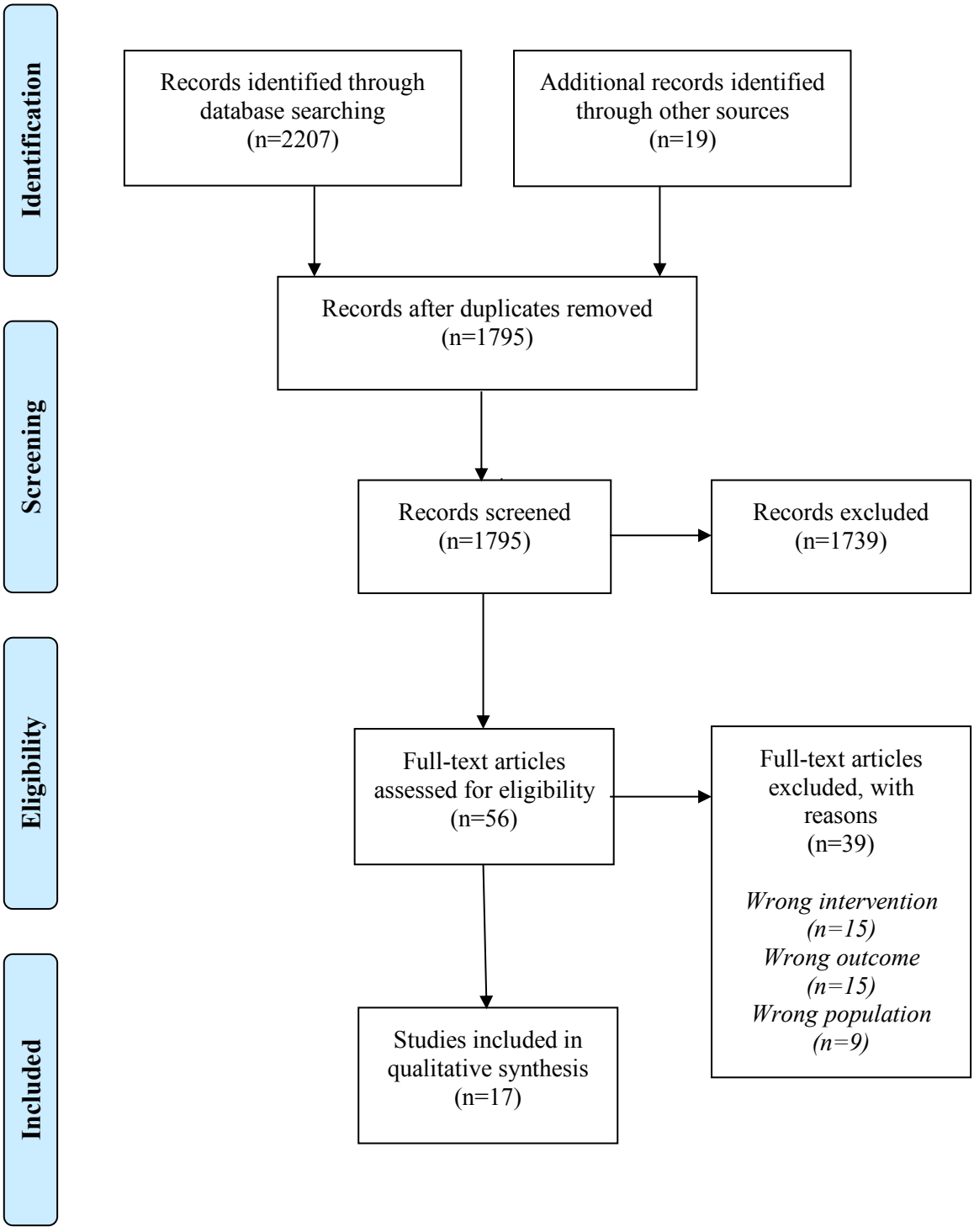

Figure 2.1. PRISMA diagram

Where available, we collected further information on the mechanism for gathering that data, such as the use of a validated survey or measurement tool. We also recorded the type of interactive tool being utilized, the number of participants, and whether it was an adult or pediatric population. One author developed the forms, which were then piloted and refined by the other two authors.

Risk of bias was assessed using ROBINS-I for non-randomized studies and GRADE for randomized studies.[31,32] Two independent screeners performed data extraction and risk of bias assessment using Qualtrics.[70] Discrepancies were resolved through discussion with a third screener. Due to the heterogeneity of the studies, meta-analysis was not possible.

2.4. Results

The combined search strategies identified 1,795 electronic records for the title and abstract screening phase, which yielded 56 potentially eligible studies for full-text screening. Of these, 17 met the study inclusion criteria and were included in the final qualitative synthesis phase (Figure 2.1).

Ten studies explored the use of interactive pain management systems in an adult population, four in a pediatric population, and three included both an adult and pediatric population. There were 12 randomized controlled trials (RCTs) and 5 non-RCTs. All studies were published in English and three studies were conducted outside of the United States.

2.4.1 Study Quality

Results of the risk of bias assessment for RCTs are reported in Figure 2.2. Only one trial was at low risk of bias for all quality criteria[71] while all others included some unclear

or high risk of bias for some quality criteria. The risk of bias assessment for non-randomized studies is reported in Figure 2.3. Overall, the majority of studies were found to have an unclear risk of bias.

(A)

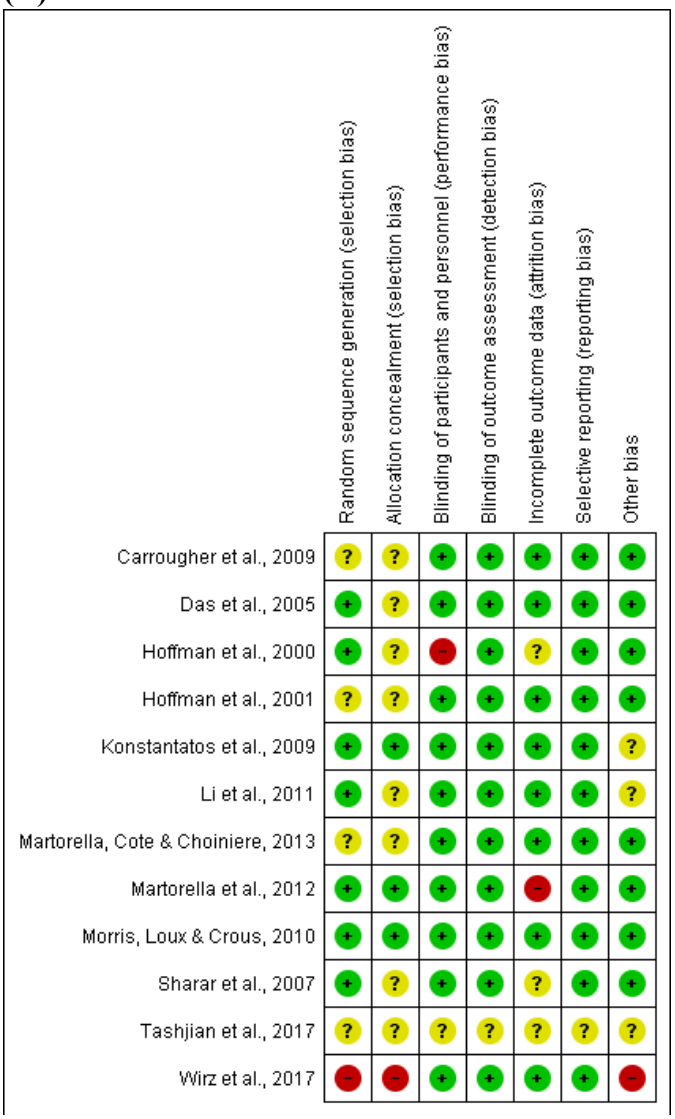

Figure 2.2.A The risk of bias assessment with GRADE for Randomized Controlled Trials. Risk of bias summary

(B)

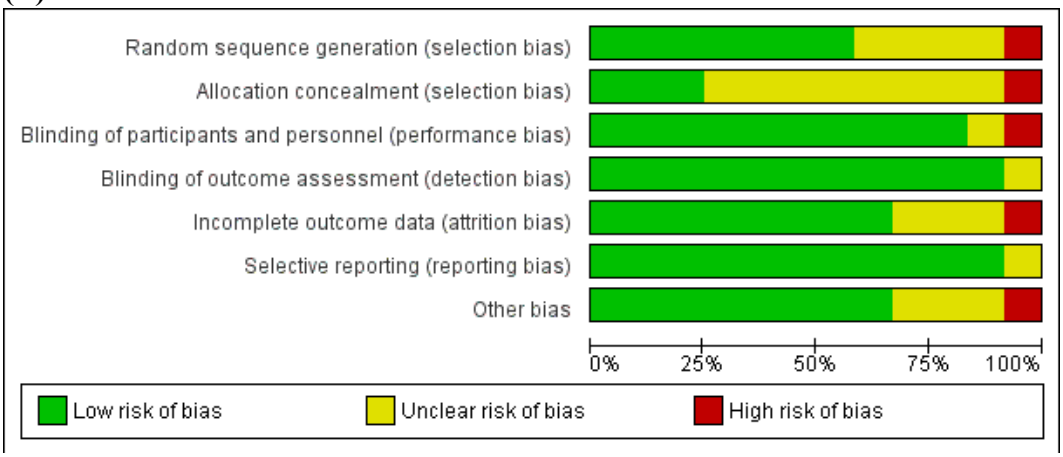

Figure 2.2.B The risk of bias assessment with GRADE for Randomized Controlled Trials. Risk of bias graph

(A)

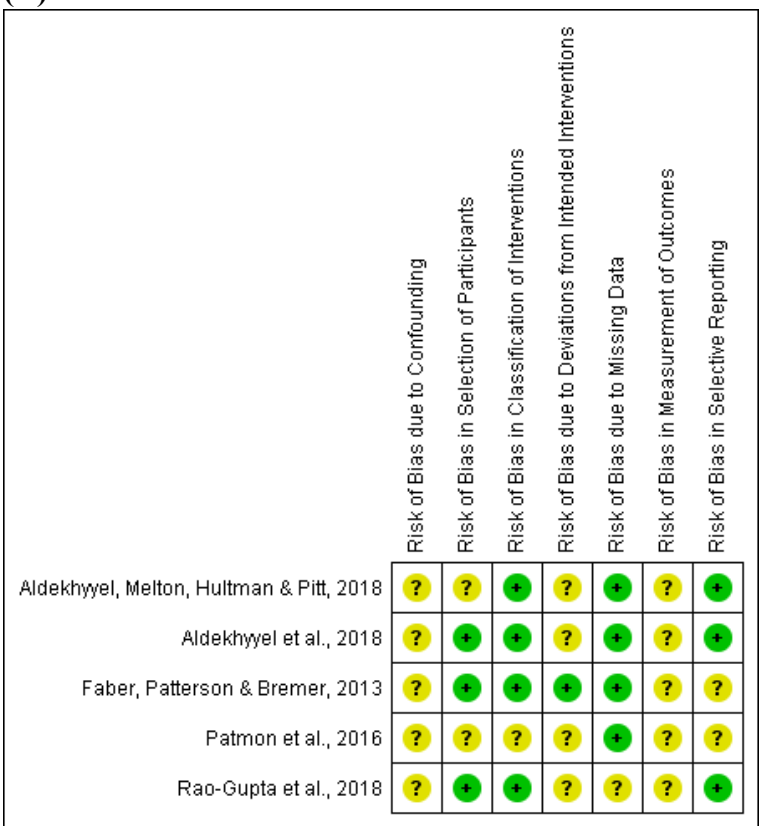

Figure 2.3.A The risk of bias assessment with the ROBINS-I tool for Non-Randomized Controlled Trials. Risk of bias summary

(B)

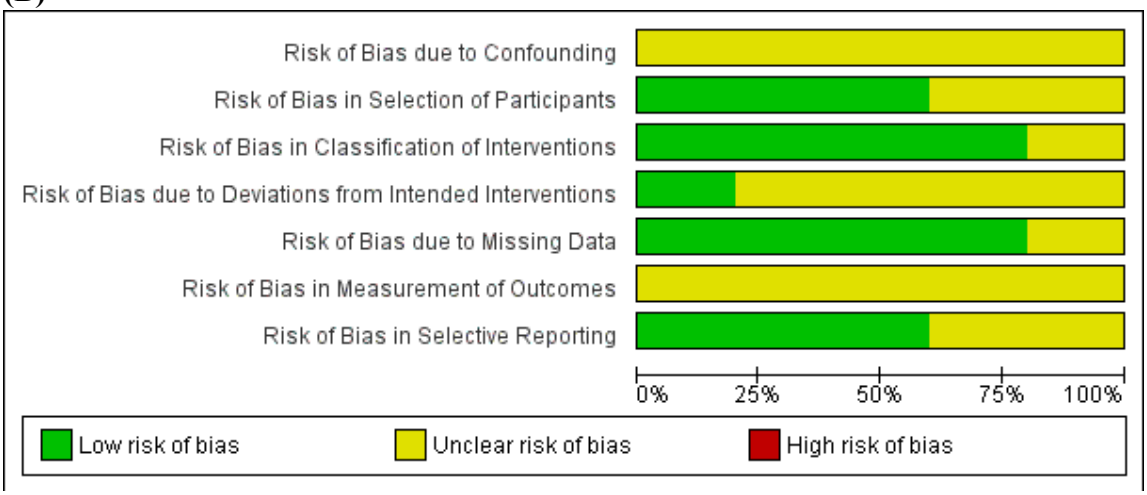

Figure 2.3.B The risk of bias assessment with the ROBINS-I tool for Non-Randomized Controlled Trials. Risk of bias graph

2.4.2 Types of Pain Management Interactive Systems

There were two main types of pain interactive systems described: stand-alone systems (systems designed to include one specific function) and platform systems (systems designed to include more than one function). These are summarized in Table 2.1 and described further below.

Table 2.1. Details of Reviewed Studies

Author	Category	Patient population	Brief description	Experimental type	Number of participants/ sample	EHR integration
Tashijian et al., 2017	Entertainment/ Distraction System	Adult	Analyzed the impact of a one-time 3D VR intervention vs. a 2D distraction video on patients suffering from acute abdominal pain with an average pain score of ≥3/10.	Randomized	50 patients in each group (total=100 patients)	No
Faber, Patterson &Bremer, 2013	Entertainment/ Distraction System	Pediatric & Adult	Explored whether VR via distraction reduces pain during more than one wound care session per patient at regional burn unit in the Netherlands.	Non-Randomized	36 patients	No
Li et al., 2011	Entertainment/ Distraction System	Adult	Explored the effects of music therapy on pain reduction in patients with breast cancer after radical mastectomy at a surgical unit in China. Patients in the control group chose their preferred music, controlled music volume and listened through a headphone connected to the MP3 player.	Randomized	60 patients in each group (total=120 patients)	No
Morris, Loux & Crous, 2010	Entertainment/ Distraction System	Adult	Examined feasibility and potential effect of a low-cost VR system, used with pharmacological analgesia, on reducing pain in adult burn patients undergoing physiotherapy treatment, compared to pharmacologic analgesia alone at a South African hospital.	Randomized	11 patients	No
Carrougher et al., 2009	Entertainment/ Distraction System	Adult	Described the effects of adding VR to standard therapy in adult burn patients receiving active-assisted range of motion physical therapy, by assessing pain scores before and after therapy on two consecutive days.	Randomized	39 patients	No
Konstantatos et al., 2009	Entertainment/ Distraction System	Adult	Examined whether pre-procedural VR guided relaxation added to PCA with morphine reduced pain severity during dressings changes in burns patients.	Randomized	43 patients in each group (total=86 patients)	No
Sharar et al.,2007	Entertainment/ Distraction System	Pediatric & Adult	Examined efficacy and side effects of VR distraction analgesia and patient factors associated with VR analgesic efficacy in burn patients who require ROM physical therapy. Study participants being pooled from 3 other unpublished studies.	Randomized	88 patients	No

Das et al., 2005	Entertainment/ Distraction System	Pediatric	Investigated whether VR, decreases procedural pain with acute burn injuries in which patients acted as their own controls though a series of 11 trials.	Randomized	7 patients	No
Hoffman et al., 2001	Entertainment/ Distraction System	Pediatric & Adult	Compared the efficacy of VR with the efficacy of a conventional treatment during at least three separate therapy sessions with multiple burn patients.	Randomized	7 patients	No
Hoffman et al., 2000	Entertainment/ Distraction System	Adult	Explored use of VR to distract burn patients from pain during physical therapy treatment. Each patient spent 3 minutes of physical therapy with no VR and 3 minutes of physical therapy with VR.	Randomized	12 patients	No
Martorella et al., 2012	Communication/ Educational System	Adult	Investigated the preliminary effects of a virtual nursing web-based intervention to improve pain relief in patients undergoing cardiac surgery. The intervention includes a preoperative 30-minute Web-based session and 2 brief face-to-face postoperative sessions. The Web application generates reflective activities and specific educational messages designed in accordance to patients' beliefs and attitudes. The messages are transmitted through videos of a virtual nurse, animations, stories, and texts.	Randomized	30 patients in each group (total=60 patients)	No
Martorella, Cote & Choiniere, 2013	Communication/ Educational System	Adult	Reported the development, validation, feasibility and acceptability of a virtual nursing web-based intervention for postoperative pain self-management in adults scheduled for cardiac surgery. The intervention includes a preoperative 30-minute Web-based session and 2 brief face-to-face postoperative sessions. The Web application generates reflective activities and specific educational messages designed in accordance to patients' beliefs and attitudes. The messages are transmitted through videos of a virtual nurse, animations, stories, and texts.	Randomized	30 patients in each group (total=60 patients)	No
Wirz et al., 2017	Personalized PCA device	Adult	Evaluated the safety, efficacy, and usability of a novel PCA dispenser, which provides pain medication at the bedside. The device has three main features; a drug dispensing unit, a radio frequency identification wristband- used for patient's registration and a PillBox, which is a patient-specific, mouth-actuated, disposable receptacle, from which the patient receives the pill.	Randomized	27 patients in the test group (total= 70 patients)	No

Aldekhyyel et al., 2018	Interactive Platform System	Pediatric	Described the implementation of an interactive tool used for pain management which allows for real time patient reported pain assessments through inpatient television screens, which is integrated with the hospital's EHR, medication dispensing machine and the nursing phones. The study measured the effects of implementation by extracting pre and post implementation pain assessment data (22 months) from the EHR.	Non-Randomized	56 931 patient records (2447 unique)	Yes
Aldekhyyel, Melton, Hultman &Pitt, 2018	Interactive Platform System	Pediatric	Described end-users (nurses & parents) perspectives on using an interactive pain management tool to report pain using a mixed-methods approach. The tool integrated 4 stand-alone technologies (EHR, medication dispensing machine, nurse phones and inpatient TV screens).	Non-Randomized	30 parents and 59 nurses (total = 89 users)	Yes
Patmon et al., 2016	Interactive Platform System	Adult	Described the perceptions of nurses who use an interactive tool in their daily work. This specific tool is built for patient-provider communication, patient access to the EHR, patient education, and distraction therapy. This tool is accessed through IPads in the outpatient clinics and through television screens in the inpatient rooms.	Non-Randomized	38 nurses	No
Rao-Gupta et al., 2018	Interactive Platform System	Pediatric	Described a quality improvement project to develop new workflows to integrate an interactive patient care technology system (designed for the management of pain accessed through the inpatient television screens) with the hospital's automated medication dispensing system and integrate the system with the hospital's EHR.	Non-Randomized	NA	Yes

2.4.2.1 Stand-alone Interactive Systems

There were 12 stand-alone interactive systems described, of which nine focused on the use of VR designed to distract burn patients from pain during physical therapy sessions [67,71,72,73,74] or wound/dressing changes.[75,76,77] One system described using interactive music therapy,[78] and another described a web-based virtual nurse designed for patient-provider communication and patient education.[79] Finally, one paper described a personalized patient-controlled analgesia (PCA) device for oral medications.[80]

VR distraction systems.

Hoffman *et al* published the earliest studies (conducted in 2000 and 2001) that examined the use of VR by burn patients during physical therapy sessions.[67,74] Studies that followed examined the efficacy of using VR in controlling pain in children with acute burn injuries,[77] factors that influenced the efficacy of VR in distracting patients during physical therapy,[73,72] and examined whether pre-procedural VR guided relaxation added to morphine-reduced pain severity during dressings changes in burn patients.[76] Later studies focused on testing the feasibility and potential effects of a low-cost VR systems in reducing patient pain during physiotherapy in a developing country,[71] examined the repeated use of VR to control pain during wound dressing changes,[75]and studied the impact of VR on patients suffering from acute abdominal pain.[81]

Interactive music.

Among the reviewed studies that examined the use of entertainment/distraction in the management of pain during therapy, Li *et al* was the only study that described the use of an interactive music therapy intervention.[78] The intervention was designed to allow patients to choose their preferred music, control music volume, and listen through a

personal headphone connected to an MP3 player. The authors reported the effects of the intervention on reducing pain after radical mastectomy in cancer patients in China.

Communication/educational systems.

Two studies investigated the development of a virtual nursing web-based intervention to improve pain relief in cardiac surgery patients and reported on the preliminary effects of the system.[42,45] The Web application generates reflective personalized activities and specific educational messages designed for patients based on their beliefs and attitudes. The system messages are transmitted through videos of a virtual nurse, animations, stories, and texts.

Personalized PCA device.

One study described a novel oral PCA dispenser providing on demand pain medication at the bedside. The device has three main features: a drug dispensing unit, a radio frequency identification wristband used for patient's registration, and a PillBox; "a patient-specific, mouth-actuated, disposable receptacle from which the patient receives the pill".[80]

2.4.2.1 Interactive Platform Systems

There were four studies describing the use of interactive platform systems built to support patient engagement and timely nursing pain reassessment documentation practices. Two described the effects of integrating an interactive platform system, accessed through the inpatient television screens, with the hospital's electronic health record (EHR) system, medication dispensing machine, and the nursing staff call system. [83,84] The third study described a similar interactive platform system for bedside pain reporting through the television; however, the system was not integrated with the nursing staff call system.[85] The

fourth study described the perceptions of nurses who use an interactive system via iPads and televisions in their daily work.[86] This system was mainly built to support patient-provider communication and patient access to the EHR.

2.4.3 Outcome Measures

We extracted 28 outcome measures from the 17 papers ranging between one to four outcomes per study. These outcomes mapped to five themes: 1) changes in patient reported pain levels; 2) patient engagement; 3) user satisfaction; 4) changes in clinical workflow; and 5) changes in clinical documentation practices.

2.4.3.1 Stand-alone Interactive Systems

VR and interactive music distraction systems.

Studies that described the use of VR and interactive music as an entertainment/ distraction intervention for the management of pain all reported changes in patient reported pain levels, as a main outcome measure, using a Visual, Graphical, Numeric, or a modified Faces Pain Rating Scale. A total of 8 out 9 VR distraction pain management intervention studies reported a statistically significant decrease in patient reported pain level scores (Table 2.2).[81,75,71,72,73,77,67,74] Konstantatos *et al* was the only study that reported that use of VR guided relaxation during dressings changes resulted in higher pain scores when compared to the use of morphine alone ($p = 0.003$) (95% CI 0.6–2.8).[76]

Table 2.2. Reported Outcome Measures from Reviewed Studies

Author	Category	Outcome measures		
		Main outcome	**Measurement**	**Main findings**
Tashijian et al., 2017	Entertainment/ Distraction System	1- Changes in patient reported pain levels	Pre- and post-intervention pain scores	Across all patients the mean pain reduction in the VR cohort was greater than in controls (-1.3 vs. -0.6 points, respectively; p=0.008). In sub-group of GI patients, mean pain reduction in the VR cohort (pre=5.72, post=4.18; p=0.016). In multivariable regression analysis adjusting for age, race, ethnicity, and gender, VR remained a predictor of pain reduction independent of pain origin (β coefficient=-0.65 points; 95% confidence intervals=-1.3 to 0; P=0.05).
Faber, Patterson &Bremer, 2013	Entertainment/ Distraction System	1- Changes in patient reported pain levels	Visual Analog Thermometer (10 cm tall burn-specific pain rating device)	Pain ratings during wound debridement were statistically lower when patients were in VR on days 1, 2, and 3, and although not significant beyond day 3, the pattern of results from days 4, 5, and 6 were consistent with the notion that VR continues to reduce pain when used repeatedly.
Li et al., 2011	Entertainment/ Distraction System	1- Changes in patient reported pain levels	General Questionnaire and Chinese version of Short-Form of McGill Pain Questionnaire. Visual Analogue Scale, and Present Pain Intensity scores.	Pain scores were measured at baseline and three post-tests. The primary endpoint was the change in the Pain Rating Index (PRI- total) score from baseline. Music therapy was found to reduce the PRI-total score in the intervention group compared with the control group with a mean difference (95% CI) of -2.38 (-2.80, -1.95), -2.41 (-2.85, -1.96), and -1.87 (-2.33, -1.42) for the 1st, 2nd, and 3rd post-tests, respectively.
Morris, Loux & Crous, 2010	Entertainment/ Distraction System	1- Changes in patient reported pain levels	Numeric Pain Rating Scale	Patients reported a marginal (p = 0.06) to (p = 0.13) difference between the two sessions (analgesia with VR and analgesia without VR) in reducing pain.
Carrougher et al., 2009	Entertainment/ Distraction System	1- Patient engagement	0 –100mm Graphic Rating Scale.	VR object "presence" was measured. Approximately half of the patients (51.3%) rated their level of presence at greater than 35 mm.
		2- Changes in patient reported pain levels	0 –100mm Graphic Rating Scale.	VR reduced all Graphic Rating Scale pain scores (worst pain, time spent thinking about the pain, and pain unpleasantness by 27, 37, and 31% respectively), relative to the no VR condition.
Konstantatos et al., 2009	Entertainment/ Distraction System	1- Changes in patient reported pain levels	10 cm Visual Analogue Rating Scale.	The group receiving VR relaxation plus morphine PCA reported higher pain intensities during the dressing change (mean = 7.3) compared with patients receiving morphine PCA alone (mean = 5.3) (p = 0.003) (95% CI 0.6–2.8).

Sharar et al.,2007	Entertainment/ Distraction System	1- Changes in patient reported pain levels	0 –100mm Graphical Rating Scale.	Compared with standard analgesic treatment alone, the addition of VR resulted in reductions in pain ratings for worst pain intensity (20% reduction), pain unpleasantness (26% reduction), and time spent thinking about pain (37% reduction).
		2- Patient engagement	sense of "presence" (0 - 100 Graphical Analog Scale)	Children provided higher subjective reports of "presence" in the virtual environment and "realness" of the virtual environment than did adults, but age did not affect the analgesic effects of VR distraction.
Das et al., 2005	Entertainment/ Distraction System	1- User satisfaction	interviews with nurses, parents and children	General positive feedback regarding the effects of VR in distraction, which had an influence in reducing sensitivity to pain.
		2- Changes in patient reported pain levels	modified Faces Pain Scale	The average pain scores for pharmacological analgesia only was 4.1 (SD 2.9), compared to VR with pharmacological analgesia (average pain score was 1.3 (SD 1.8))
Hoffman et al., 2000	Entertainment/ Distraction System	1- Patient engagement	sense of "presence" (0 - 100 Visual Analog Scale)	Patients reported mean presence in VR was 63.67 mm, and mean realism of virtual objects was 51.92 mm.
		2- Changes in patient reported pain levels	0- 100-mm Visual Analog Scale	Patients completed five subjective pain ratings. All patients reported less pain, when distracted with VR, and magnitude of pain reduction by VR was statistically significant.
Hoffman et al., 2001	Entertainment/ Distraction System	1- Patient engagement	sense of "presence" (0 - 100 Visual Analog Scale)	Patients experiencing VR were asked after each physical therapy session. All, except one patient, reported a score above 50.
		2- Changes in patient reported pain levels	0- 100-mm Visual Analog Scale	Patients completed five subjective pain ratings. Pain ratings were statistically lower when patients were in VR, and the magnitude of pain reduction still existed with repeated use of VR.
Martorella et al., 2012	Communication /Educational System	1- Changes in patient reported pain levels	Barriers Questionnaire-II, Pain Catastrophizing Scale	Patients in the experimental group didn't experience less intense pain, but reported less pain interference when breathing/coughing (P = .04). On day 7 after surgery, participants in the experimental group reported fewer pain-related barriers: Barriers Questionnaire-II (mean 10.6, SD 8.3) than patients in the control group (mean 15.8, SD 7.3, P = .02). Both groups mean revealed lower tendency to catastrophize pain before surgery: Pain Catastrophizing Scale (control group mean 1.04, SD 0.74; experimental group mean 1.10, SD 0.95) and after surgery (control group mean score 1.19, SD 0.94; experimental group mean score 1.08, SD 0.99).
Martorella, Cote & Choiniere, 2013	Communication /Educational System	1- User satisfaction	questionnaires of acceptability with 10 multiple-choice questions	Most of participants indicated that the strategies proposed responded to their needs (96%) and that the information provided helped to control pain and lessen worries (93%).

Wirz et al., 2017	Personalized PCA device	1- Changes in clinical workflow	value-stream mapping (comparison between pre and post implementation)	Medication provision process pre-implementation comprised of 8 steps. Post implementation was 3 steps.
		2- Patient engagement	"efficacy measure"- data recorded by the device for each patient and questionnaires filled out by patients	Success rate of 90% for pill intake upon patient's request.
		3- User satisfaction	"usability measure" measured using questionnaires filled out by patients and medical staff	At least 80% of patients and medical staff were satisfied with device use and recommend its use.
		4- Changes in patient reported pain levels	0-10 Numeric Rating Scale	Patients reported pain levels before and after the pill intake using the novel PCA. Patients reported significantly less pain, both at rest and in movement, from first postoperative day.
Aldekhyyel et al., 2018	Interactive Platform System	1- Changes in documentation	% pain documentation occurrences (comparison between pre and post implementation)	A modest increase was found in the mean timely documentation rates on the basis of nursing documentation standards (26.1% vs 32.8%, a percentage increase of 25.7%; P< .001) along with decreased median time to pain reassessment documentation (29 minutes versus 25 minutes, a percentage decrease of 13.8%; P, .001).
		2- Changes in clinical workflow	value-stream mapping (comparison between pre and post implementation)	The pain management tool was developed interfacing 4 stand-alone technologies to engage patients. The workflow is triggered when pain medications are dispensed by sending an automatic pain assessment rating question via the patient's television at a predefined time.
		3- Patient engagement	usage rates based on responses to system prompts	Usage rates were low with 6.5% for the level of pain prompt and 13.3% for the other nonpharmacologic strategies to help with pain prompt.
Aldekhyyel, Melton, Hultman &Pitt, 2018	Interactive Platform System	1- User satisfaction	2 survey instruments: closed- ended (5 point Likert scale) and open-ended questions	Parents were more satisfied with the experience (90%) compared to nurses (50%). Timely reassessments of pain were the most valuable feature reported. Qualitative analysis of nurses' responses yielded 6 themes for technology benefits and 12 for challenges.
Patmon et al., 2016	Interactive Platform System	1- User satisfaction	interviews using a focused rapid ethnographic evaluation	Participants reported findings of using the system effective for distraction, great functionality for patients and nurses, has implications for clinical practice, and needs additional training to improve usage.

Rao-Gupta et al., 2018	Interactive Platform System	1- Changes in clinical workflow	value-stream mapping (comparison between pre and post implementation)	The new workflow included 2 main improvements, which included admission assessment questions for the healthcare team and system integrations between the interactive tool and the EHR and medication dispensing system.
		2- User satisfaction	proportion of "always" responses to the (Child HCAHPS, 2014-2016) pain question	Proportion of family satisfaction responses to the question ‘‘Did staff do everything they could to manage your child’s pain?’’ increased from year 2014 to year 2016 (p = .006).
		3- Changes in documentation	# documentation occurrences	Documentation of nonpharmacologic interventions: year 2014(# unique patients=2462), year 2015 (# unique patients=2684), year 2016 (# unique patients=2970).

In addition to reporting changes in patient reported pain levels as a main outcome measure, four VR intervention studies reported levels of patient engagement and one reported levels of patient satisfaction as a secondary outcome measure. Studies that reported levels of patient engagement[72,73,67,74] used a 1-100 Visual or Graphical Analog scale to measure sense of presence ("illusion of being inside the computer generated environment") and engagement while using the VR system.[67] Hoffman *et al* reported average engagement mean scores in both of their studies.[67,74] Carrougher *et al* showed that approximately half of the adult burn patients rated their level of presence and engagement with the VR during physical therapy treatment, at lower average scores,[72] while Sharar *et al* showed that children reported higher levels of engagement than adults.[73]

Among this group, only one study reported levels of satisfaction with the use of VR as a secondary outcome. The authors measured levels of satisfaction through a series of interviews with parents and nurses. Nursing staff indicated that the use of VR during wound dressing changes was helpful in distracting children from pain and "all parents agreed with the positive effects of VR in pain management for their child. They all commented that the child's anxiety level was perceptibly less when using VR, and the child looked forward to playing the VR game".[77]

The interactive music intervention study measured pain scores at baseline and three post-tests reporting on the Pain Rating Index (PRI- total) score from baseline. Music therapy was found to reduce the PRI-total score in the intervention group compared with the control group.[78]

Communication/educational systems.

The two studies published by Martorella *et al* describing the use of a virtual nursing web-based intervention for self-management of pain post cardiac surgery, reported changes in patient pain levels using the Barriers Questionnaire-II.[79] Patients in the intervention group reported fewer pain-related barriers (mean 10.6) than patients in the control group (mean 15.8, p = .02). In their follow up study, the authors reported the acceptability of the virtual nursing web-based intervention, by measuring the perceptions of patients using a questionnaire.[82] Most of the patients indicated that the strategies proposed responded to their needs and that the information provided helped control pain and lessen worries.

Personalized PCA device.

The study of the oral PCA dispenser reported an improvement in the clinical workflow from a total of eight to three steps. The authors also reported three secondary outcome measures: 1) high level of patient engagement (success rate for using the device of 90%); 2) lower patient reported pain levels during day 1 and day 2 post-operative during rest (33.56% reduction, P value = 0.0058) and movement (28% reduction, P value = 0.0012); and 3) high satisfaction with the usability of the device as indicated by both patients and medical staff (80% were satisfied).[80]

2.4.3.2 Interactive Platform Systems

Two studies describing the implementation an interactive pain management platform system accessed through inpatient television screens, reported improvements in patient pain reassessment nursing documentation practices by calculating the percent of pain documentation occurrences pre and post system implementation. The authors also reported: 1) improvement in clinical workflow by implementing nursing automatic alerts

to conduct timely reassessments of pain, and 2) low levels of patient engagement with the system by calculating system usage rates.[83] In their follow-up study the authors captured the perceptions of nurses and parents with the use of the system. Parents were more satisfied with the experience compared to nurses and both nurses and parents indicated that timely reassessments of pain was the most valuable system feature.[87]

A second group of authors described a quality improvement project to integrate a similar pain management interactive system with the hospital's EHR and medication dispensing system. The authors reported an increase in patients' satisfaction scores with the hospital's pain management initiatives, as a result of the integration. The authors also reported an increase in documentation of nonpharmacologic interventions.[85]

Patmon *et al* interviewed nurses to capture their perceptions with using an interactive patient engagement technology during their daily clinical practice. Nurses reported effectiveness of the tool for distraction therapy, satisfaction with the functionality of the tool, positive implications for clinical practice, and the need for additional training to improve usage.[86]

2.5 Discussion

Our systematic review identified the types of patient interactive systems used in the inpatient setting for the management of pain and the impact of these systems on controlling patient pain levels, hospital workflows, patient engagement, and user satisfaction. The majority of the studies included in our review were VR systems used for distracting burn patient during physical therapy treatment or wound dressing changes. These types of studies mainly reported the effects of using VR systems on controlling patient pain levels during hospitalization.

With recently published studies, we found that there is a smaller but growing body of evidence describing the use of interactive platform systems promoting self-management of pain, increasingly with integration into different hospital technology systems. These interactive systems earned positive feedback from users, increased levels of satisfaction and resulted in improved clinical workflows. Our review also revealed that interactive platform systems designed to support more than one aspect of pain management during hospitalization can potentially align with national pain management standards. Specifically, these systems may assist with increasing patient engagement in pain management treatment planning through education, providing nonpharmacologic pain treatment modalities, and facilitating reassessment and timely responses to patient's pain through automatic documentation of response(s) to pain interventions.[41] Additionally, some studies demonstrated the feasibility of integrating these systems with the EHR to support clinical documentation, create standardized fields for patient-generated pain assessment data, and allow patients to access their records. Expanding the use of these interactive platform systems for the management of other conditions may have the potential to support many patient engagement initiatives.[88,11,89,90,91]

Limitations of this review include the different definitions of interactivity, patient engagement, and outcome measures, making direct comparisons difficult. The differences in definitions, populations, and study designs led to heterogeneity, which in turn made a meta-analysis infeasible. This lack of a meta-analysis limits our ability to draw conclusions regarding the efficiency, efficacy and effectiveness of one interactive system when compared to another. The impossibility of blinding participants and assessors in these studies also introduces the possibility of bias. Finally, the five outcome measure themes

described in our review were not equally represented in the literature and were heterogeneous within outcome measure themes. Limiting our review to those articles describing only pain management interactive patient care systems and its application in the inpatient care setting likely influenced the representation of outcome measures we observed. By restricting our review, we may have also unintentionally removed meaningful details from other patient interactive systems.

We also observed a diversity in evaluation criteria and a lack of a standardized framework for measuring the efficiency and effectiveness of interactive pain management interactive systems. Improved standardized evaluation assessments will help to improve our ability broadly to assess and improve health outcomes in existing and future pain management interactive systems.

2.6 Conclusion

The use of inpatient interactive systems in the management of pain is an emerging area of interest for researchers and healthcare providers in the era of modern healthcare technology and increased focus on patient engagement. These systems have primarily been entertainment-focused and built to distract patients during a treatment procedure and have shown an impact in lowering levels of patient-reported pain scores. Inpatient interactive pain management systems integrated with the hospital's EHR further facilitate patient-provider communication, patient education, and self-reporting; they show promising effects on timely pain assessments, increasing patient satisfaction, and patient engagement. Further high-quality studies with a more standardized approach to implementation and assessment are necessary to reinforce and validate these findings.

CHAPTER 3: LINKING PEDIATRICS PATIENTS AND NURSES WITH THE PHARMACY AND ELECTRONIC HEALTH RECORD SYSTEM THROUGH THE INPATIENT TELEVISION: A NOVEL INTERACTIVE PAIN-MANAGEMENT TOOL

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3.1 Summary

Objectives: Implement a novel pain management interface which brings real-time patient reported pain assessments to the inpatient television, and evaluate the impact of implementation on the pain management clinical workflow, patient engagement, and nursing pain reassessments.

Methods: We developed a pain management tool interfacing four stand-alone technologies: a television-based interactive patient care system, electronic health record (EHR) system, nursing call system, and pharmacy inventory management system. The workflow is triggered when pain medications are dispensed by sending an automatic pain assessment rating question via the patient's television at a predefined time. To measure the effects of implementation we calculated patient/parent utilization rates and pain reassessment timely documentation rates. Data was extracted from the EHR for a period of 22 months, covering pre and post implementation.

Results: A total of 56,931 patient records were identified during the study period, representing 2,447 unique patients. The total number of parents/patients reporting their pain through the tool was 608 users. Utilization rates were 6.5% for responding to the pain rating prompt and 13.3% for the follow-up prompt offering additional non-pharmacologic strategies to eliminate pain. A modest increase was found in the mean timely documentation rates based on nursing documentation standards (26.1% vs. 32.8%, a percentage increase of 25.7%; $p<0.001$), along with decreased median time to pain reassessment documentation (29min vs. 25min min, a percentage decrease of 13.8%); $p<0.001$).

Conclusion: This novel tool offers a potentially scalable approach in supporting the pain management clinical workflow, integration of technologies, and promoting patient/parent engagement in the inpatient setting.

3.2 Background

Hospitals increasingly rely on stand-alone health information technology (HIT) systems to carry out complex clinical workflows.[19,28,29,92–96] As failure for these systems to work together can affect patient safety and quality measures, integrating stand-alone technology systems to improve workflows has become an emerging focus of many healthcare systems.[97]

The workflow surrounding inpatient pain management is emblematic of many inpatient clinical workflows; it is complex, patient-focused, and involves multiple disciplines including providers, pharmacists, and nurses.[98] Accurate and timely documentation of pain assessments is essential for improving the overall quality of patient care,[99] and is explicitly laid out as a clinical standard by different hospital regulatory bodies,[8,38,41,100,101] including those specifically focused on pediatric hospitals.[9,10] Additionally, current national recommendations are focusing on strategies to reduce the prescription of opioids for patients and increase the use of non-pharmacologic therapy for pain.[102]

In this paper, we describe the implementation of a novel pain management interface (PMI) at a large pediatric hospital, built to engage patients/parents, support automatic pain assessment documentation in EHR, and help ensure a patient-centered experience. By demonstrating the feasibility of successfully integrating multiple HIT systems to address inpatient pediatric pain, and notably including realtime patient/parent feedback directly into the workflow, we provide a proof of concept for other hospitals to consider as they look to make the best use of existing inpatient technologies.

3.3 Methods

3.3.1 Pain Management Interface Development

The University of Minnesota Children's Hospital is a 246-bed free-standing quaternary care mother and children's hospital. In 2011, we implemented a stand-alone television-based pediatric interactive patient care (IPC) system that helps inpatients/parents interact with their healthcare providers through their bedside television screens.[103] This system serves as the primary gateway for patient entertainment, standardized disease-specific patient education, and care communication. In 2014, our hospital's EHR vendor allowed for bidirectional communication with the IPC system, which provided the opportunity to develop new integrations. To determine the feasibility of integrating these technologies, we chose to create a new pain management workflow, which would allow us to pilot and evaluate the integration capabilities using patient-facing real-time feedback.

Prior to the implementation of the PMI, the pain management clinical workflow involved the patient/parent reporting pain to the nurse directly, either by pressing the nurse call button or during routine assessments. The nurse would reassess the patient at a pre-defined time (depending on the route of medication) and document this reassessment in the EHR.

Our new PMI workflow integrated four independent inpatient technologies: the IPC system, EHR system, nursing call system, and pharmacy inventory management system to allow for time-triggered patient reporting of pain assessments. To set the PMI triggers, we adopted the hospital's nursing pain reassessment policy, which indicating that nurses are required to document patient response to specific medication interventions within the onset to peak effect period for the medication given in the past 24 hours (i.e. between 15-35

minutes for intravenous pain medications; 30-65 minutes for oral pain medication).[104]

The new PMI workflow (Figure 3.1) was designed to work as follows:

1) A pain medication is dispensed from the pharmacy inventory system;

2) This triggers a timer based on the medication route (i.e., 15 minutes for intravenous pain medications and 30 minutes for oral pain medications);

3) After this time has elapsed, a pop-up window appears on the patient's television screen, which reads: "*A little while ago, you got medication for pain. Please tell us how you're feeling now: a) Hurts More, b) Hurts the Same, or c) Hurts Less"*;

4) After the patient/parent responds to the question, results are immediately communicated to the nurse's phone and automatically documented in the EHR. Nurses then perform a required hands on pain reassessment and document accordingly in the EHR.

5) The system then displays a follow up message linking the patient/parent to other non-pharmacologic standardized resources embedded within the IPC system.

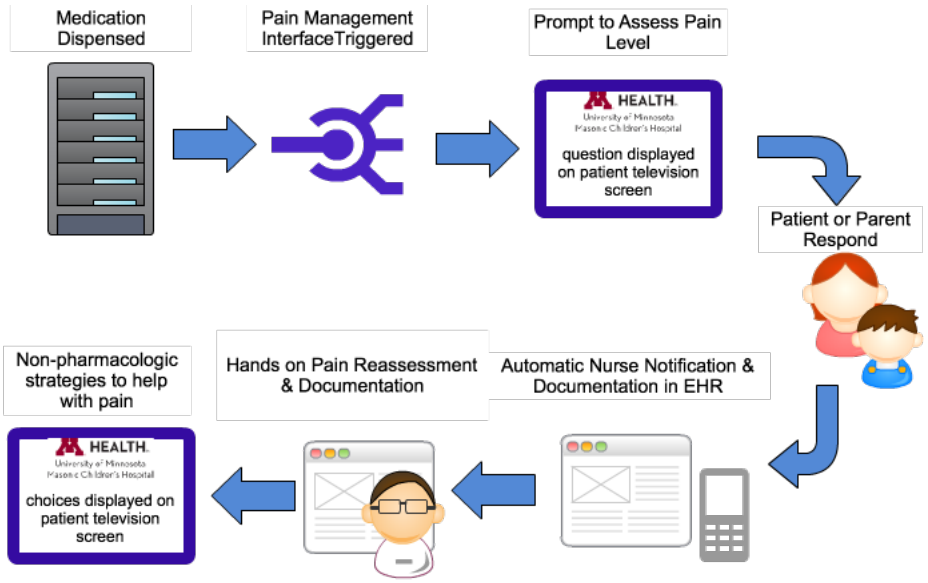

Figure 3.1. Overview of the IPMS clinical workflow

3.3.2 Evaluation

With institutional review board approval, we employed a retrospective dataset analysis to calculate patient/parent utilization rates and nursing pain reassessment documentation rates by extracting records from the University of Minnesota Research Clinical Data Repository.

The dataset included all pediatric inpatient records stored in an institutional based EHR covering a 22-month period (pre-PMI implementation period from January 1, 2014 through November 29, 2014 and a post-PMI implementation period from January 1, 2015 through November 29, 2015). To allow for an initial startup period and for analysis purposes, December data were not included.

To calculate patient/parent utilization rates, we calculated the number of responses to the two questions triggered by the IPC system after medication is given. These include (1) the level of pain and (2) other non-pharmacologic strategies to help with pain. To

measure the nursing pain reassessment documentation compliance rates, we calculated the (1) frequency (i.e., did nurses document a reassessment at all?), and (2) timeliness (i.e., was compliant documentation occurring within the hospital's pain reassessment timeframe standards?).

In order to measure nursing pain reassessment documentation frequency, we examined the dataset to identify the presence or absence of nurse documentation values stored in the EHR. To measure timeliness of documentation, we compared the time stamps of nursing pain reassessment documentation against the standard documentation timeframe. Records were deemed to be compliant if they had a nursing pain reassessment documentation value present and within the documentation standard timeframe.

3.3.3 Analysis

We calculated frequencies and percentages based on the presence or absence of nurse documentation values and patient/parent pain-rating responses, and calculated medians and ranges for time measurements. We used the Chi-square test to compare the nurse's documentation frequency rate and documentation compliance rate to other categorical factors. P-values less than 0.05 were considered statistically significant. Statistical analysis was performed using SAS version 9.3 (SAS Institute Inc., Cary N.C.).

3.4 Results

During the study period, 56,931 records (2,447 unique patients) had at least one pain medication administration (29,707 pre-PMI implementation and 27,224 post implementation).

3.4.1 Patient/Parent Utilization Rates

A total of 608 unique patients/parents engaged with the PMI by responding 1,767 out of the 27,224 times a television prompt for pain assessment was triggered (6.5%). Forty-five percent of the users were adolescents between the ages of 10-18 years, 54% male, and 75% identify as White race. Additionally, there were 3,632 patient/parent responses of 27,224 follow-up non-pharmacologic prompts (13.3%). (Table 3.1)

Table 3.1. Patient/Parent Responses to the Helping With Pain Question

In Addition to Medicine, There Are Other Things That Can Help With Pain	Responses (*N* =3632) *n(%)*
Things I can do right now	**3557 (97.9)**
Use ice or heat	3483 (97.9)
Try different resting positions	15 (0.4)
Practice deep breathing techniques	14 (0.4)
Relax using aromatherapy oils	13 (0.4)
Ways I can find comfort	32 (0.9)
Things I can sign up to do later	**75 (2.1)**
Things that help me focus away from pain	60 (80.0)
Integrative health and wellbeing	6 (8.0)
Guided imagery	1 (1.3)
Energy therapies	8 (10.7)

3.4.2 Changes in Nursing Timely Pain Reassessments

Table 3.2 summarizes the frequency and timeliness of nursing pain reassessment documentation, comparing pre and post PMI implementation.

There was a modest increase in nursing documentation (3.1% relative increase; $p<0.001$) in the period post intervention; however, overall nursing documentation rates remained low at 53.4%. When documentation was present, the median [min;max] time of documentation was 29.0 min [1;120] pre-PMI and 25.0 min [1;120] post-PMI (p-value<0.001). There was a relative 25.7% increase in compliance rates during the post PMI period ($p<0.001$). Nurses were more likely to document pain reassessments when patients/parents reported pain

through the tool, with documentation occurring 63.4% of the time when the PMI had been used vs. 52.7% of the time when it had not, a relative difference of 18.4% ($p<0.001$).

Table 3.2. Nursing Pain Reassessment Documentation Rates (Documentation Frequency and Timeliness)

	Pre PMI, *n* (%)	Post PMI, *n* (%)	% Change	*P*
Documentation Frequency				
Documentation Present				
No	14,322 (48.2%)	12,690 (46.6%)	-3.3%	
Yes	15,385 (51.8%)	14,534 (53.4%)	+3.1%	<0.001
Total	29,707	27,224		
Documentation Timeliness				
Non-compliant	11,371 (73.9%)	9,762 (67.2%)	-9.1%	
Compliant	4,014 (26.1%)	4,772 (32.8%)	+25.7%	<0.001
Total	15,385	14,534		

3.5 Discussion

Our pilot describes an innovative approach to patient/parent engagement in the management of pain in a pediatric inpatient hospital setting. To our knowledge, little has been explored in the use of IPC systems to assist in pain management, particularly in the context of inpatient pediatric care.[105]

Beyond the successful proof of concept that four freestanding HIT systems could integrate successfully, our study demonstrated three key findings. First, although overall pain reassessment documentation rates remained relatively low, documentation rates post PMI implementation showed a slight, statistically significant improvement. While a modest gain in documentation would not be a reason alone to implement this integrated PMI, pairing with other non-technology interventions may facilitate and address documentation barriers.

Second, the ability to capture the non-pharmacologic pain management needs of our hospitalized patients may prove valuable for future pain management initiatives to engage patients/parents to in their care[106,107] and meet regulatory compliance.[4] Lastly, while implementation of the PMI demonstrated relatively low use by patients/parents, PMI use by patients/parents was associated with a significant 20.3% relative increase in pain reassessment documentation rates. This highlights that the intervention may assist nurses in timely documentation. Efforts to increase the PMI's use among patients/parents may lead to further increases in documentation compliance.

Our study has several limitations. The PMI workflow relies on several assumptions including that the television is on, the viewer is awake, is literate in English, and that users are comfortable navigating the bedside remote. If any of these assumptions is not valid for a particular encounter, the workflow would revert to reliance on the nurse to reassess without a patient trigger. Additionally, our study was performed at one facility with a focus on a specific population, which may reduce generalizability of the findings.

3.6 Conclusion

We demonstrated that integrating four stand-alone inpatient technologies was feasible for developing a novel clinical workflow for supporting the pain management process at our children's hospital and engages patients/parents in the workflow. As pediatric hospitals aim to meaningfully engage patients/parents, integrations such as these may prove beneficial in supporting real time patient-driven communication that interfaces with existing technologies.

CHAPTER 4: USING A BEDSIDE INTERACTIVE TECHNOLOGY TO SOLICIT AND RECORD PEDIATRIC PAIN REASSESSMENTS: PARENT AND NURSING PERSPECTIVES ON A NOVEL WORKFLOW

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4.1 Summary

To measure the impact of a novel interactive inpatient pediatric pain management solution integrating our hospital's electronic health record system, the nurse communication phones, and the pharmacy dispensing system, we assessed parent and nurse perspectives on the tool's potential value, benefits, and challenges. A mixed-methods approach with survey instruments containing closed-ended and open-ended questions was administered to 30 parents and 59 nurses (66% and 23% response rate respectively). Overall, parents were more satisfied with the interactive technology experience (90%) compared to nurses (50%) with both indicating timely reassessments of pain being the most valuable feature. Qualitative analysis of nurses' responses yielded 6 themes for technology benefits and 12 for challenges. While patient-interactive technology solutions appear well-received particularly by parent end-users for pediatric hospital pain management, nurse training and interface improvements may result in higher efficacy, ultimately empowering patients/parents, promoting patient engagement and satisfaction.

4.2 Background

Healthcare delivery in the United States continues to shift to a patient-centered approach, with increased attention being paid in how to engage patients in the use of their medical data including access to their electronic health record (EHR).[108–111] Initially, larger efforts from a policy and EHR vendor perspective have focused on patient-facing health information technology (HIT) tools to provide patients with access to their clinical notes and results from laboratory and imaging tests as well as communicate with their providers and other members of their healthcare team.[112] Recently, a number of patient-centered HIT tools allow for the capture of patient-generated health data and outcomes (e.g., home blood pressure or blood glucose levels). [113,114] Ultimately, integrating patient-reported data into the EHR may drive better patient outcomes, assist providers in their clinical documentation practices, and support researchers by improving the quality of EHR data.[109,115] Thus far, however, most of this integration has been limited to outpatient patient/provider systems.[93,116]

In the inpatient setting, the use of interactive patient care (IPC) tools accessed at the patient's bedside including thru the television or other bedside devices is beginning to emerge.[19,117] These IPC tools are often also used as an entertainment platform for patients, by delivering on-demand video and game content, with the added benefit of other virtual patient care interactions such as patient tailored-information delivery through the bedside television (e.g., disease specific educational videos, guided imagery) by the care team selectively assigning content.[118] In most cases, however, IPC tools are stand-alone technology lacking EHR integration limiting the ability to support real-time and meaningful bi-directional interfaces to affect patient care.[38,119]

To improve our ability to provide timely information delivery particularly around pain control, we successfully integrated our inpatient television-based IPC with three other stand-alone HIT systems (the EHR system, the nurse communication phones, and the pharmacy dispensing system) at our children's hospital, and leveraged this integration to engage parents in their reporting of their child's pain through a time-triggered television pop-up pain reassessment which was communicated to the nurses' phone and documented within the EHR.

After implementing this solution, timely documentation of nursing pain reassessment increased 26% compared to the prior year.[120] While this was a statistically significant increase in timely nursing documentation, the overall utilization of the IPC reassessment by patients was low (6.5%). In this study, as this type of patient-centered television-based workflow was previously unreported and the factors contributing to low utilization were unknown, we sought to gain insight from end-users by gathering the perspectives of nurses and parents using this novel interactive pain management tool. This study has the potential to aid in further modifications of the workflow and technology as well as provide broader learnings for improved user experience and utilization for similar IPC tools.

4.3 Methods

4.3.1 Hospital Setting and the Pain Management Solution

The University of Minnesota Masonic Children's Hospital is a 246-bed comprehensive quaternary children's and mother's hospital and is part of Fairview Health Systems. In 2014, the hospital piloted a novel pain management solution, which was developed internally to integrate four stand-alone technologies: a television-based IPC

system[103], the EHR system, a nursing call system, and the pharmacy inventory management system. The solution was implemented on four units within the hospital: the intensive care unit, bone marrow transplant unit, and two medical/surgical units that care for a variety of general pediatric and subspecialty patients. The motivations behind developing this system were: (1) to pursue transformative strategies to eliminate pain, (2) activate an additional tool to alert nurses when it was time for pain reassessment and documentation, (3) provide a tool for patients and their families to alert their nurse about the perception of pain and effectiveness of interventions, improve regulatory compliance and efficiency, and (4) reduce variation in access to pain management resources.

4.3.2 Clinical Workflow

Prior to the launch of the new interface, the pain management clinical workflow was mostly manual with no system triggers. The patient/parent reported the level of pain by calling for the nurse, or the nurse identified pain as a problem while interacting with the patient. The nurse was then required to document the pain rating score in the EHR, check pain medication orders, and select and administer the appropriate medication. To conduct patient pain reassessment, the nurse was required to anticipate the medication peak, (which varies for each medication), performs the reassessment, and document the pain rating in the EHR. If pain was still an issue indicated by the patient/parent, the nurse selected an additional intervention (another medication, and/or non-pharmacological support, and/or contact a physician).

After the new interface was implemented, the pain management clinical workflow starts proactively. Once the patient and family are in the admission room, the IPC shows a brief video to set expectations about pain, pain management options, and the partnership

between family and the hospital care team in managing pain. When the patient is prescribed pain medications, the nurse first removes the medication from the medication dispensing machine. This initiates a time-based trigger (i.e. 30 minutes for oral pain medications and 15 minutes for intravenous pain medications) for a pop-up window to be displayed on the inpatient television screens showing a pain rating question. Once the patient or parent responds to the question using the television remote or a keyboard, the patient's pain rating score is communicated to the nurse through their phone and automatically documented in the EHR. Nurses access and interact with the system through their phones and the inpatient computer stations, while patients or parents use the remote bedside clickers or keyboards and their television screens to access and interact with the system.

4.3.3 Study Design

We used a mixed-method concurrent triangulation approach for this study. Since the experience with the pain management tool differs between nurses and parents, we developed two survey instruments with questions specific to each user's experience. We built the surveys in Qualtrics@UofM[70] and used questions based on examples of other patient and provider technology user experience and satisfaction surveys.[107,121,122] After a pilot study was conducted, surveys were adjusted based on participants' comments and feedback.

The nurse survey instrument was developed to capture closed ended and open-ended responses. There were 14 closed-ended questions in multiple-choice format designed to collect demographic information, experience with computers, and the perceived usefulness of the tool on a 5-point Likert scale (1=not at all useful to 5=extremely useful). There were 2 open-ended questions designed to capture the experience, benefits

and challenges of the tool as perceived by nurses. Nurses were eligible if they had experience with using the solution for at least a month. Invitation emails were sent through the hospital's nursing email distribution list in December 2015. Reminder e-mails were sent approximately 1, 2, and 3 weeks after the initial e-mail invitation. Upon completion of the survey, nurses were given a $10 gift card.

The patient survey instrument included 32 close-ended questions in multiple-choice format designed to collect demographic information, experience with computers, satisfaction with nursing pain management communication, and the perceived usefulness of the tool on a similar 5-point Likert scale. Based on the feedback received from parents during the pilot study, open-ended questions were omitted from the survey instrument in an effort to minimize time burden of the parents of inpatient children. Parents were eligible if they were 18 years of age or older, used the interactive tool to report their child's pain for two times or more, and were fluent in English. Parents were surveyed using convenience sampling in which 2 informatics researchers (RA and GH) were notified of inpatient families who met inclusion criteria, and if available and the parents provided informed consent, the researchers administered the survey orally using hand held devices. Participating parents were able to choose from a variety of small gifts valued at under $10 for themselves and their children.

The study was approved by the University of Minnesota Institutional Review Board and the University of Minnesota Masonic Children's Hospital Nursing Research Council. The study was conducted over a 6-month period starting from December 2015.

4.3.4 Data and Statistical Analysis

The responses to the Likert scale items were analyzed through the Qualtrics website to produce descriptive statistics. Additional analysis was performed in SAS version 9.3 (SAS Institute Inc., Cary N.C.). Non-parametric Spearman correlation, the non-parametric Wilcoxon rank sum test, and the Kruskal-Wallis test were used to assess differences between subgroups. Comparison groups were constructed based on participant demographics with findings being considered statistically significant at $P < 0.05$. Only correlated items at $R > 0.5$ are reported in study.

To understand nurses' responses to the open-ended questions, two reviewers (RA and MP) conducted a thematic content analysis. Reviewers looked for repetition and statements relevant to benefits and challenges with using the solution. Next, the reviewers met together and identified a single set of themes via consensus and created standardized codes for the themes along with a set of definitions. To increase validity and comprehensiveness of the themes, each reviewer independently reviewed the themes while examining the original data. Lastly, each reviewer coded the entire original data independently and then a meeting was convened to reach 100% agreement and consensus between inconsistencies. The final codes were then reviewed and sorted on the basis of the thematic content. The analysis lasted 4 weeks, with 2 group meetings during that period.

4.4 Results

4.4.1 Participants

4.4.1.1 Parents

A total of 30 parents, who met the inclusion criteria were approached to participate during the study period. Twenty parents (66%) agreed to participate. Table 4.1 summarizes parent demographics.

Table 4.1. Parent Participant Demographics

Characteristic		*n* (%)
Gender		
Female		**16 (80)**
Male		4 (20)
Parent Age (years)		
< 30		5 (25)
30-39		**8 (40)**
40-49		4 (20)
50-59		3 (15)
Ethnicity		
Caucasian		**14 (70)**
African American	3 (13.0)	2 (10)
Asian	2 (8.7)	2 (10)
Native American	2 (8.7)	2 (10)
Education Level		
Less than high school		2 (10)
High school graduate or GED		2 (10)
Some college		**7 (35)**
College graduate		5 (25)
Postgraduate degree		4 (20)
Income		
<35K		5 (25)
35-49.9K		2 (10)
50-74.9k		4 (20)
75-99.9K		1 (5)
100K +		**6 (30)**
General level of computer experience		
Less experienced (e.g., browse web, check email, or less)		1 (5)
Somewhat experienced (e.g., edit photos, use spreadsheet)		**12 (60)**
Very experienced (e.g., create web page, write computer programs, or more)		7 (35)
Patient (child) Age (years)		
<5		5 (25)
5-11		5 (25)
>11		**10 (50)**

Admission inpatient unit	
ICU	2 (10)
Medical/Surgical, Hem Onc, Transplant	6 (30)
Medical/Surgical, Cardiac, Other Specialties	**12 (60)**
First admission	
Yes	6 (30)
No	**14 (70)**
Length of Stay	
>3	4 (20)
3-4	5 (25)
5-6	3 (15)
7-8	2 (10)
> 8	**6 (30)**
Prior use of the pain management interactive tool	
Yes	**12 (60**)
No	8 (40)
Number of times the interactive tool was used during the current inpatient stay	
2-3	**10 (50)**
4-6	5 (25)
> 6	5 (25)
Knowledge of the non-medication patient education resources available through the system	
Yes	**12 (60**
No	8 (40)

Note: Bold numbers indicate the highest value within a specific group

4.4.1.2 Nurses

Although the exact number of email addresses on the hospital's email distribution list was unknown, there were around 260 registered nurses (RN) and nurse technicians working in the 4 inpatient units included in this study. Fifty-nine nurses (23%) participated in the study. We accepted completed surveys from participants who self-identified as RNs. The survey took an average of 8 min to complete. The majority of nurses indicated they were somewhat experienced with computers (83%, n = 49) such as using spreadsheets, and (80%, n = 47) indicated having more than 6 months experience in using the pain management solution. Nurse participant demographics are provided in Table 4.2.

Table 4.2. Nurse Participant Demographics

Characteristic	*n* (%)
Gender	
Female	**57 (97)**
Male	2 (3)
Age (years)	
< 26	9 (16)
26-34	**36 (62)**
35-54	11 (19)
55-64	2 (4)
Inpatient hospital unit	
ICU	3 (5)
BMT	13 (22)
Medical/Surgical, Hem Onc, Transplant	9 (15)
Medical/Surgical, Cardiac, Other Specialties	**34 (58)**
Previous experience with adult patients	
Yes	14 (24)
No	**45 (76)**
General level of computer experience	
Less experienced (e.g., browse web, check email, or less)	8 (14)
Somewhat experienced (e.g., edit photos, use spreadsheet)	**49 (83)**
Very experienced (e.g., create web page, write computer programs, or more)	2 (3)
Experience working with the pain management interface tool (months)	
2	1 (2)
3	5 (9)
4	3 (5)
5	3 (5)
>6	**47 (80)**
Knowledge of the non-medication patient education resources available through the system	
Yes	**37 (62)**
No	22 (37)

Note: Bold numbers indicate the highest value within a specific group

4.4.2 Perceived Usefulness of the Tool

4.4.2.1 Parents

Most of the parent participants were satisfied with the general experience of using this interactive tool to manage their child's pain (90%), indicating that it helped their nurse manage their child's pain in a more timely manner (75%), and many (45%) felt the tool helped them better understand their child's pain. Additionally, half of the parents indicated the tool led to access to non-pharmacologic alternative resources for pain control including

video/visualization resources embedded in the bedside TV entertainment system (Figure 4.1).

Several differences among parent sub-groups were identified in relation to the perceived usefulness and general satisfaction with the tool. Parent age was found to be negatively correlated with the usefulness of the tool in helping the nurse know the level of child's pain (R= -0.52, p=0.02) with younger parents being more satisfied. Results also indicated a correlation between the overall level of satisfaction with the use of the tool and the overall satisfaction with the nursing pain management communication activities. This correlation was found in 5 out of 9 statements that asked parents about levels of satisfaction with specific nursing pain management communication activities: (1) time to discuss concerns in using the tool (R=0.61, p=0.004), (2) ability of the tool to communicate the level of pain to the nurse (R=0.66, p=0.002), (3) nurse listening regarding child's pain (R=0.58, p=0.007), (4) nurse assessment of child's pain (R=0.65, p=0.002), and (5) nurse concern with child's emotional and physical wellbeing (R=0.60, *p=0.005)*

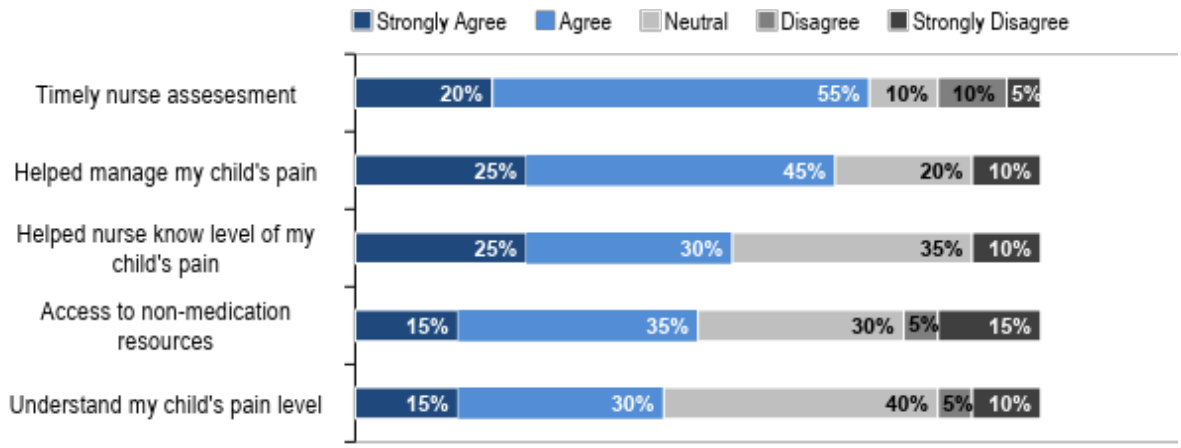

Figure 4.1: Perceived usefulness of the tool based on parents' responses

4.4.2.2 Nurses

Results from the nursing survey indicated that 50% of the nurses were generally satisfied with the use of the pain management tool, 40% were indifferent, and 10% indicated dissatisfaction. When nurses were asked about the perceived usefulness of the tool, timely reassessment reminders and phone triggers were the top useful features (Figure 4.2).

We identified several differences among nurse sub-groups with respect to perceived usefulness and general satisfaction with the tool. Nurses with experience working with adults scored lower for reassessment of patient's pain (p=0.028) and for general satisfaction with the tool (p=0.052). General satisfaction with the tool varied among the hospital units (p=0.034), with the Medical/Surgical, Hematology Oncology, Transplant Unit scoring highest and the Bone Marrow Transplant Unit scoring the lowest.

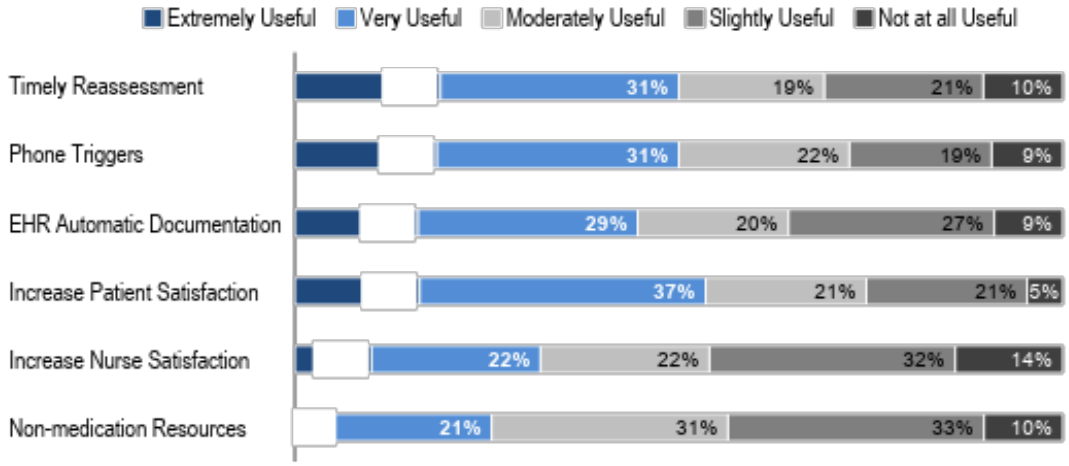

Figure 4.2: Perceived usefulness of the tool based on nurses' responses

4.4.2.3 Nurse Perspectives on the Benefits and Challenges of the Solution

All nurses participating in the study provided a total of 118 responses to the open-ended questions related to the benefits and challenges of using the tool. A total of 45 unique nurse statements were derived and coded from responses to the benefits question, with thematic analysis yielding 2 main themes: (1) nurse benefits and (2) patient benefits (Table 4.3).

Having phone reminders to reassess patient pain was the most frequently mentioned benefit (n=16) with one nurse stating: *It reminds me to check back with my patients in the appropriate window of time following a pain med (oral or IV)"* and another stating, "*Sometimes it can be a reminder to check in on patients after giving an oral pain medication; especially if it is within a busy shift*." Several nurses (n=8) cited that the system supported patient empowerment and satisfaction. For example, "…[it] *gives the patient/family more control over pain management,*" "*…there is definitely value in participating in voicing their pain level through this avenue*."

Nurses also described several challenges with using the tool, with 112 unique nurse statements derived and coded from responses to this question. These challenges were mapped to 4 main themes: (1) nurse related, (2) system related, (3) patient related, and (4) organization related.

The most frequent challenge described by nurses (n=16) was uncertainty of patient-rating score. Nurses described concern that patients/parents are using the tool mainly to make the pop-up pain-rating question disappear so that patients continue using the entertainment feature of the system rather than accurately reporting the level of pain. For example one nurse stated, "*If patients don't use it, or just click buttons to get message to*

go away. Wonder about accuracy in describing pain." and another stating, "*I feel as though most pts just push a button on the GWN to continue watching their program and dont honestly answer at their true pain level*".

The second highest challenge was system related, indicating low utilization of the system among both nurses and patients/parents-unspecified reason (n=15). Some examples of nurse statements include, "…*it is very rare that a patient will actually use the Get well network*® [IPC vendor name] *to reassess their pain*.", and "*I don't see a lot of families clicking the multi-modal pain management strategies button.*"

Patient related challenges included low utilization due to patient factors (i.e, age, language, technology comfort) (n=14). Examples of nurse statements include, "*Sometimes it is irrelevant because alot of my patients are too young to read.*", and another "*It is rarely used properly on the PICU* [Pediatric Intensive Care Unit] *because our patients are so sick they are unable to utilize the tool.*"

Table 4.3. Benefits and challenges to the use of the pain management tool

No.	Category	Example	Count
Benefits			
1. Nurse benefits			**28**
1.1	Phone reminder to reassess patient pain	*"Super helpful in reminding me to reassess and document..."*	16
1.2	Auto documentation within the EHR	*"I like that when the pt responses to their pain after an intervention that it charts it in Epic…"*	6
1.3	Decision support to prioritize patients' needs	*"... If I get a message that pain is increased, I know to prioritize and get back into the room sooner to intervene..."*	6
2. Patient benefits			**17**
2.1	Empowerment and satisfaction	*"...I think there is definitely value in participating in voicing their pain level through this avenue…"*	8
2.2	Sense of connection	*"... its nice that it lets you know where your patients pain is at after a medication."*	5

2.3	Non medication resources	*"…The best resources in the non-medication section of the GWN are videos …"*	4
Challenges			
1. *Nurse related*			**33**
1.1	Uncertain of patient rating scores	"some patients will click the first button they see to get rid of the pop up and it will ding to us that their pain is worse..."	16
1.2	Less experienced with system /need more training	*"Getting all info i need to use it to it's full capability"*	11
1.3	Distraction from other tasks	*"… And as a nurse I also find the alerts that come to my phone as annoying. Its just another "beep" on my phone that distracts me from patient care.*	4
1.4	Discourage best practice - (pain assessment/reassessment documentation)	*"…it can never replace the need for a nurse with training a permission to use non-medication pain management…."*	2
2. *System related*			**39**
2.1	Low utilization (unspecified reason)	*"some patients/families do not report the reassessment of pain."*	15
2.2	Low utilization due to environmental factors	*"the biggest challenge is the TV being broken-then I can't use the interface."*	13
2.3	System design limitations	*"Organization of the non-pharmacological pain interventions. Would be easier to have a quick link or to assign these modules…"*	8
2.4	Discrepancy pain scales between patient rating and nurse assessment	*"…Hence it would be great if the tool used in the GWN could follow the same suit as the one used in Epic."*	3
3. *Patient related*			**20**
3.1	Low utilization due to patient factors (i.e-age, language, technology comfort)	*"some dont know how to navigate or use it cause they are too young, i see some adults but mostly little kids."*	14
3.2	Patient annoyed/dissatisfied/uninterested with the tool	*"Some patients have expressed annoyance with the question always popping up on their televisions."*	6
4. *Organization related*			**20**
4.1	Extra work and does not improve overall workflow	*"…it doesn't save us any time or steps."*	11
4.2	Duplicate charting requirement	*"… I wish that there was a way to verify it or co-sign it so that we didn't have to double chart their response."*	9

The last main theme was coded as being related to the organization and included challenges related to workload and overall clinical workflow (n=11). Nurses described this challenge

in statements such as *"making sure phones are logged in correctly each shift (one more thing the charge RN has to do)…"* and *"Honestly, it is one more sign-in to have to do…"*.

4.5 Discussion

The importance of capturing the perceptions of parents, as consumers, is as important as capturing the perceptions of nurses. Or and Karsh[107] specifically addressed the main factors that influence consumer acceptance, while other studies examined the effects of introducing health information technology tools on providers.[123,124] Our objective was to study the perspectives of both parents and nurses towards using an interactive patient care tool in the management of pain at our children's hospital.

Our main findings indicate cohesive agreement among parents and nurses on the perceived usefulness of the pain management tool. Both indicated that the most usefulness feature of the tool was its ability to support timely reassessment of patients' pain. Similarly, this feature was the top mentioned benefit that emerged from our qualitative analysis. These findings can be viewed as a factor of successful implementation, as it is aligned with one of the main reasons for implementing this solution. While both parents and nurses indicated that the non-medication pain management resources accessed through the IPC tool was the least useful feature, in comparison to the other system's features. It is worth noting that this may be a result of a lack of familiarity with this tool. Inexperience with using the full set of features of the solution and the need for more training has emerged as one of the challenges that nurses face with the tool. This is similar to the finding of other research studies examining the challenges to interactive technology adoption.[86,96]

Although demographic group differences in parents' perceived usefulness of the tool were not found to be clinically significant, results indicated a correlation between

parents' satisfaction with nursing pain management communication activities and the general satisfaction with the use of the tool. These findings are similar to other findings examining the relationship between that satisfaction with HIT tools and provider communication.[112]

Interestingly, nurses recognized the value of this solution in engaging and empowering patients and their families, increasing patient satisfaction, and creating a communication platform for patients and families to voice their perceptions of pain. This was aligned with the parents' perspectives, which showed the majority of the surveyed parents satisfied with the experience of using the tool and indicated that it provided a good method to communicate their child's pain to their nurse.

Many of the challenges that nurses stated suggested a desire for system improvements that would better support nursing pain management care and documentation, rather than resistance to the use of the tool. Nurses indicated uncertainty of the patient pain response scores as the number one challenge. In response to this concern, system changes were done to the pain rating pop-up question in order to change the default display value "hurts less" to "hurts more". This change has increased the variability of the patient responses documented in the EHR, which in turn may address this challenge. Educating the patient/parent on the benefits of using the tool and the contribution they make in the pain management process is another vital method that can potentially address this concern.

Low utilization of the tool among patients/parents emerged as a second challenge. This was also found in our previous system's evaluation study.[120] Similar to other study findings[86,96] , more education and training is needed to remind nurses about the existing

features of the system and how to navigate and educate patients and families about the benefits of using the tool. Other nurses stated challenges related to the duplicate charting requirement and extra work during their shift. Although one of the reasons for developing this solution was to engage patients in their pain management care and support the nursing pain reassessment process, nurses were expecting the tool to replace pain reassessment documentation in the EHR. The overall sense of apprehension among nurses can be partially explained by lack of understanding of the main driver behind implementing this solution. Published literature has highlighted the importance of education for end-users in HIT system implementation, noting that inadequate familiarity and knowledge may potentially lead to user frustration.[123]

Limitations of this study include the relatively small sample size of the participants and our inability to calculate the nurses' response rate. Although we intended to be as systematic as possible in reaching as many nurses as we could, the exact number of nurse emails were unknown and the perspectives were limited to those nurses who were able to open their work emails on the days and times when messages to participate in the study were sent. Also, the study was limited to one institutional setting; pediatrics. Therefore, future research should explore these findings in an adult setting, where patient factors related to patient age might not be a challenge.

Future studies using time-motion or work sampling techniques may examine the amount of time nurses spend using the solution in their clinical practice and the impact of the tool on time efficiency in documentation practices and patient education. We also plan to conduct a patient/parent usability study to determine what areas can be improved to make the interface easier to use.

4.6 Conclusion

To our knowledge, this is the first study to assess parent and nurse perspectives on the implementation of an interactive tool developed to support the pain management clinical workflow within an inpatient pediatric setting. Our results could inform other health care organizations about the feasibility of and potential areas to focus on when implementing an interactive tool integrated with other HIT systems. We found that parents were satisfied with the use of the tool, highlighting its importance as a communication tool with nurses and its effect on timely reassessments of their child's pain. Nurses recognized the tool's importance in increasing patient engagement and satisfaction but also expressed some concerns about its validity in reporting patient pain scores. Inpatient interactive tools have the potential to increase patient engagement and communication with clinicians; however, if education and training are not given to end-users, the full benefits of these tools many not be realized. In addition, our findings indicate that nurses are in favor of the solution's ability to automatically store patient pain reassessments in the EHR, suggesting that future interface changes to the pain rating question may be helpful in supporting pain reassessment documentation practices.

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CHAPTER 5: UNDERSTANDING THE PEDIATRIC INPATIENT POPULATION USE OF PATIENT INTERACTIVE TOOLS IN THE MANAGEMENT OF PAIN

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5.1 Introduction

The ability of pediatric patients and their parents to contribute to the management of their care during a hospital stay is crucial for better health outcomes and increased care satisfaction.[125] While some interactive patient care (IPC) tools are designed to place patients in an active and engaged role in their health, this does not guarantee that these systems will be used. Understanding the end user – in this case pediatric patients and their parent proxies – is essential in developing meaningful IPC tools. We previously developed and implemented a novel pain management IPC solution where patients are prompted to report their pain rating scores via an inpatient television screen after the administration of pain medication with the response sent to the nurse's phone and documented in the electronic health record.[120] We wished to learn more about the population that utilizes IPC tools by conducting a retrospective analysis of inpatient records covering a twelve-month period. We sought to detect differences in patient responses across different demographics in order to better understand use patterns and potential improvement areas.

5.2 Methods

Inpatient medical records from the University of Minnesota research Clinical Data Repository were extracted. The study sample included all University of Minnesota Masonic Children's Hospital (UMMCH) inpatients with at least one of the following: (1) inpatient admission at UMMCH between January 1 and December 31, 2016; (2) pain medication administrated that triggers the IPC tool to collect patient pain responses; and (3) response to the pain-rating question (representing usage of the tool).

The number of pain-rating responses per patient was examined with respect to patient age, gender, race, inpatient unit, pain medication administration route, and

medication administration time and inferential statistics applied to detect differences in use. Non-parametric Spearman correlation and Wilcoxon rank sum were used to evaluate the association between patient demographics and responses per patient. Chi-square tests were used for categorical factors, including pairwise comparisons between categories. P-values less than 0.05 were considered statistically significant.

5.3 Results

A total of 16,775 patient records were included in the dataset, representing the total number of pain medication administrations during the study year. A total of 1,563 patient pain responses were recorded via the IPC tool (representing 681 unique patients) resulting in usage rates of 9.3%. Table 5.1 illustrates the association between patients' demographics and patient pain rating responses.

Table 5.1. Patient Demographics and Response per Unique Patient, N=681

Patient Age category	**N (%)**	**Mean**	**SD**
0-5	273 (40.09%)	1.4	3.4
6-10	121 (17.77%)	3.1	6.2
11-15	129 (18.94%)	3.1	6.6
16+	158 (23.20%)	2.6	3.7
Patient Gender			
Female	353 (51.84%)	2.4	5.5
Male	328 (48.16%)	2.2	4.0
Patient Race			
Non-White	162 (23.79%)	1.6	3.0
White	485 (71.22%)	2.6	5.4

The non-parametric Spearman correlation between age and responses per patient showed a weak but statistically significant positive correlation ($r=0.20$, $p<.001$). Wilcoxon rank sum for patient gender (p-value=0.897) and patient race (p-value=0.004) was statistically non significant ($p<.001$).

Table 5.2 examines the association between patient responses and other characteristics (*presenting only statistically significant values).* After adjusting for multiple comparisons most pairwise comparisons resulted in a p<0.001.

Table 5.2. Association Between Patient Use (responses) and Other Characteristics

Characteristic	Patient responses /Total meds given	(%)	p-value
Hospital Unit			
Pediatric ICU (Peds ICU)	(71/858)	(8.28%)	**p<0.001**
Peds ICU vs. Cardio ICU /Peds ICU vs. Med-Surgery HEM *			
Cardiovascular ICU (Cardio ICU)	(33/1171)	(2.82%)	**p<0.001**
Cardio ICU vs. BMT / Cardio ICU vs. HEM / Cardio ICU vs. Med-Surgery Cardiac *			
Pediatric Bone Marrow Transplant (BMT)	(254/4236)	(6.00%)	**p<0.001**
BMT vs. Med-Surgery HEM / BMT vs. Med-Surgery Cardiac *			
Medical/Surgery Hematology, Oncology, Transplant (HEM)	(552/4416)	(12.50%)	
Medical/Surgery Cardiac, Other Specialties	(652/5862)	(11.12%)	
Medication Administration Route *			
Intravenous	(743/11164)	(6.66%)	**p<0.001**
Oral	(820/5611)	(14.61%)	**p<0.001**
Medication Administration Time			
T1: 12:00 am -6:00 am	(90/3840)	(2.34%)	**p<0.001**
T1vs.T2 / T1vs.T3/ T1vs.T4 *			
T2: 6:01 am- 12:00 pm	(385/4259)	(9.04%)	**p<0.001**
T2 vs. T3 / T2 vs.T4 *			
T3: 12:01 pm- 6:00 pm	(517/4421)	(11.69%)	
T4: 6:00 pm-11: 59 pm	(571/4255)	(13.42%)	

* Chi square p-value<0.001

Higher usage of the IPC tool was found among patients that were given an oral pain medication compared to intravenously (p-value<0.001). All pairwise medication

administration time comparisons had $p<0.001$, except for 12:01 pm- 6:00 pm vs. 6:00 pm-11:59 pm (after adjusting for multiple comparisons).

5.4 Discussion

Our findings provide valuable insight into which patients may be more likely to utilize an interactive tool for the management of pain. First, a difference was found in patient usage among different hospital units based on the care and medical service they provide (i.e., intensive care vs. non intensive care). Examining the specific clinical workflows and educational efforts that are provided to patients upon admission on the use of the IPC tool may be valuable for better understanding why significant differences were found between these units. Second, increased usage was associated with the time of medication administration. We speculate that this may be because in the late hours and early morning that many times televisions are off (which is where the pain-rating trigger is displayed for patients) resulting in lower usage rates in the daytime. Also, parents/caregivers may not be available during the early morning time to help children respond to the pain-rating trigger. Lastly, while older pediatric patients were more likely to use the tool to report pain and a weak correlation was found between different patient age groups and the use of the IPC tool, utilization rates among all age groups is needed.

Ultimately, this work not only adds to our published research on understanding some of the barriers and facilitators of adoption of the tool by parents[126;] but also potentially uncovers opportunities for designing educational programs tailored to the characteristics and preferences of patients and their parents/caregivers to increase patient engagement in a pediatric inpatient hospital setting. Future work involves exploring the relationship between patient reported ratings and nursing pain reassessment values.

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CHAPTER 6: CONCLUSIONS

The ability to potentially improve clinical outcomes of patients with chronic diseases, through the use of interactive technology systems, has been studied previously by many.[125,127,128] We aimed to address the gap in literature related to the vastly understudied area that focuses on the ability to utilize these systems within an inpatient hospital setting for managing acute pain and examining their impact on clinical outcomes, patient satisfaction, and hospital workflows.

The purpose of this study was to understand the current state of inpatient IPMS and evaluate their impact on hospital workflows, patient clinical outcomes, and patient satisfaction. This work also evaluated the impact of implementing a novel IPMS at the UMMCH, as a case study. Evaluating the impact of implementation from different perspectives demonstrated that an inpatient interactive system can be utilized for the management of pain, which is integrated with the hospital's EHR system to promote patient engagement, increase nursing clinical documentation, and patient satisfaction.

The results of our systematic literature review detailed in the first paper highlighted the current state of utilizing patient interactive systems for the management of pain in an inpatient hospital setting. We examined a variety of outcome measures to determine the effects of utilizing different IPMS. These measures included changes in patient reported pain levels, patient engagement, user satisfaction, changes in clinical workflow, and changes in documentation. In the 12 systems, which measured patient pain reported scores, 11 demonstrated a positive impact on lowering the levels of patient reported pain. While, the majority of the reviewed papers focused on the use of interactive systems as a method to distract patients from pain during a hospital procedure, other systems demonstrated the

potential impact of using IPMS for other purposes such as increasing patient engagement, communication with providers, and supporting clinical documentation.

Our case study, reported under chapters three, four and five, focused on describing a novel inpatient interactive system at the UMMCH used by patients/parents to report pain scores to nurses. The system is accessed by patients/parents through the inpatient television screens and is integrated with the hospital's existing health information technology and biomedical device infrastructure (EHR, nursing communication phones and the pharmacy inventory management system). The purpose of the case study was to evaluate the system and describe its effects on (1) the frequency of nursing pain reassessment documentation and (2) timeliness of pain reassessment documentation in accordance with the hospital's pain reassessment documentation standards. We also conducted further research to explore the perceptions of users with the use of the system (nurses and parents) as well as understand the population of users and what factors may potentially increase their use and interaction with the system.

Our findings demonstrated that integrating four stand-alone inpatient technologies was feasible for developing a novel workflow for supporting the pain management process at the UMMCH that engages patients/parents. Similar to the use of patient engagement technologies[129], the utilization of the IPMS at the UMMCH was low. Despite low utilization, there were statistically significant increases in the frequency and timely compliance of pain reassessment documentation by nurses. Other unstudied factors may have contributed to this increase, such as culture change that may have occurred as a result of implementing the interface or the automatic phone triggers that serve as a reminder to

document or due to human factors related to how nurses are trained to react to different levels of pain as indicated by patients/parents.

Successful implementation of HIT systems depends mainly on users' attitudes and satisfaction with the use of the system. [130–132] In our third and fourth studies the aim was to assess the perceptions of both nurses and parents in the use of the IPMS, by conducting two surveys, and to better understand the population of users by conducting a retrospective analysis of patients' records. Results of the survey showed that parents were generally satisfied with the use of the tool, highlighting its positive effect on receiving timely nursing care when their child is in pain. While nurses recognized the role of the tool in increasing patient engagement and satisfaction, they also expressed some concerns about the validity of the patient/parent self-reported pain scores. Increasing educational efforts designed specifically for patients and their parents, emphasizing the importance of patient engagement and their role in accurately reporting pain levels, may potentially assist in increasing reliability of PROs stored in the EHR.

We demonstrated valuable insights into which patients may be more likely to utilize an interactive tool for the management of pain, by the retrospective analysis of patient records. When comparing usage of the tool among different patient users based on hospital characteristics, two main differences were found; (1) difference between patients admitted to intensive care units and patients admitted to non-intensive care units, and (2) increased usage was associated with the time of medication administration (day-time vs. night-time). Examining the differences in clinical workflows among hospital units may be valuable for better understanding why significant differences were found.

Providing increased control to patients directly at their bedside via a television-based interactive system shows some promise at implementing best-practices where the care team, patients, and the EHR intersect. These findings provide guidance for other health care organizations to understand the complex factors of implementing inpatient IPMS, to develop a user-friendly system, to address the nurses' and patients'/parents' needs and concerns, and to understand the feasibility of and potential areas to focus on when implementing an interactive pain management system in an inpatient hospital setting. Additionally, this study served as a successful proof of concept of the integration of different stand-alone inpatient technologies that may have clinical implications beyond pain reassessment and documentation.

There were a number of limitations in this research. Due to different definitions of interactivity, patient engagement, and outcome measures, direct comparisons between the reviewed papers was difficult in the systematic review research paper. The differences were also found in the study designs, which led to heterogeneity, making infeasible to conduct a meta-analysis. Restricting the review to articles that described only IPMS and its application in the inpatient care setting likely influenced the representation of outcome measures described in the study.

Another limitation of this research is that the evaluation studies were limited to a single pediatric inpatient setting of an academic institution and a small sample size representing nurses and parents as the main users of the IPMS. As a consequence, our findings are limited by lack of generalizability. Further research is needed to confirm that these findings holds for other organization's pain management interactive systems and for different populations such as the adult population. Exploring the effects of IPMS within

different hospital settings and among different populations may serve as method to generalize our findings.

Future directions include a IPMS post-implementation follow-up study to specifically measure the impact of utilizing the IPC tool for reporting pain, on the patients' pain scores and on the nursing pain reassessments taking into account patient diagnosis codes. Additionally, despite the automatic documentation of patient pain responses, nurses are still required to document their own formal reassessment in a separate field in the EHR. Exploring the relationship between the patient's/ parent's self-reported pain reassessment responses to the value scores documented by the nurse in the EHR may potentially allow for changes in the clinical workflow. If scores are consistently congruent, changes in the patient pain assessment question to reflect a formal pain assessment scale may become more visible. This would free up nurses to perform other patient care responsibilities and have an impact on clinical workflows.

Overall, this work demonstrates the diversity in system features that are provided to inpatients by different IPMS and the variability in measuring the effects of these systems on patient outcomes, as reported in our systematic review study and other published research. This in turn contributes to the lack of a standardized framework for measuring the efficiency and effectiveness of IPMS, making it difficult to evaluate these systems against each other. Our future work will focus on the development of a standardized evaluation method, which will help in improving the ability to broadly assess the impact of existing and future IPMS on patient health outcomes in general and on improving patient reported pain levels in specific. Evaluating the effects of these systems on clinical outcomes, patient satisfaction, hospital workflow, and barriers and facilitators associated

with the use of these systems is an important component in developing meaningful HIT systems to engage patients and address pain.

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